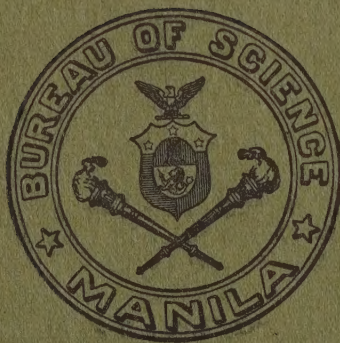


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AN OUTBREAK OF HÆMORRHAGIC SEPTICÆMIA IN INDIAN BUFFALOES

By TEODULO TOPACIO¹

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TWO PLATES

In 1912 Mohler and Eichhorn reported the use of septicæmia vaccine in the control of an outbreak of hæmorrhagic septicæmia among the buffaloes in Yellowstone Park. From all indications the epizootic occurred some time in 1911.

In the Philippines all outbreaks of septicæmia that have come to official notice so far occurred among cattle and carabaos. Since the introduction of Indian buffaloes into this country in (1903), (1) as far as our records are concerned, the outbreak reported in this paper is the first of its kind studied in the field and diagnosed in the laboratory.

June 14, 1938, a letter was received by Director Gregorio San Agustin, of the Bureau of Animal Industry, from Dr. Pedro de Guia, Superintendent of the Bongabong Stock Farm, Nueva Ecija, reporting the sudden death of a 4-year grade Indian buffalo. This animal was reported missing on the night of the previous day when the herd of 150 heads was counted in the corral. On inspection of the pasture the animal was found dead. The carcass was located and in an advanced stage of decomposition, with the four legs stretched, rigid, and spread apart. Anthrax was suspected by Dr. Angel C. Dizon, farm veterinarian, who, without opening the carcass, collected blood

¹ Died in Manila, June 19, 1939.

smears from the ear vein and jugular vein for microscopic examination. His findings were negative, and seven smears that were forwarded to the Veterinary Research Laboratory for diagnosis again proved negative. The same day another animal, a 10-month-old bull calf, was found moribund. When it died, smears taken from the spleen proved negative on microscopic examination. The remainder of the fresh smear, including two blood smears, were again forwarded to the laboratory for examination and diagnosis. The specimens were once more found negative on microscopic examination. From June 13 to June 20 seven animals died. The blood of the seventh animal was again found negative.

Due to the repeated failures in laboratory examinations to determine the causative microorganisms, it was strongly suspected that septicæmia was responsible for the malady. Hæmorrhagic septicæmia vaccine and anthrax vaccine were shipped to Bongabong with instructions to apply the hæmorrhagic septicæmia vaccine first, pending a final diagnosis. June 20 all buffaloes in the herd were given a single dose of hæmorrhagic septicæmia vaccine. With Drs. A. B. Coronel and Miguel Muñoz, I went to Bongabong for close study of the situation and ocular examination of any recent carcass in the pasture. During two days of inspection in the buffalo herd pasture, all the carcasses seen were in an advanced stage of putrefaction. One of these showed some fresh parts of the body, and smears were obtained from the inguinal vessels and precrural glands which appeared to retain scarlet blood. On examination at the Provincial Hospital Laboratory at Cabanatuan (through the courtesy of Doctor Isip, Director) some Gram-negative bipolar organisms were observed in the smears. Although these findings were by no means conclusive, a telegram was sent to the Director of Animal Industry, stating that "all indications are septicæmia," pending an autopsy of a fresh case.

DISPOSITION OF CARCASSES

All carcasses found in the pasture by the joint party showed putrefaction in harmony with the description given in the preceding paragraph. In nearly all cases they were found at the brim of the mud wallows, suggesting intense thirst on the part of the sick animals shortly before death. It was difficult if not impossible to distinguish the picture of the entire situation from a similar view in an anthrax outbreak. It is in cases such as

these that only the finding and isolation of the causative agent by laboratory methods will settle a dispute or a doubt in the field. The scouting party in a unit arranged field incineration of the carcasses, taking advantage of the liberal supply of firewood lying about the pasture. In every case this was accomplished on the spot. Not being able to find a fresh carcass for nearly 48 hours, we returned to the laboratory pending further developments.

FINAL DIAGNOSIS

June 23, 1938, Dr. Ventura Gatchalian, District Veterinarian of Nueva Ecija and in charge of the vaccination work in the farm, reported the death of a 10-month-old calf 48 hours after vaccination. The carcass was found by him still warm, so he collected fresh blood and a piece of spleen, packed the specimens in ice and sent them to our laboratory, where they arrived at about 4:30 P. M. of the same day. Smears from the blood and spleen were stained and immediately examined microscopically, and again all turned out negative. A series of 2 rabbits, 2 guinea pigs, 2 rats, and 2 mice were gathered and given a subcutaneous injection of blood and another subcutaneous injection of saline suspension of spleen at the rate of 5 cc, 5 cc, 1 cc, and 1 cc, respectively. The next morning after the injection all these animals were found dead. Microscopic examination of their heart blood showed teeming numbers of Gram-negative bipolar organisms of hæmorrhagic septicæmia. The microphotograph in Plate 1 is self-explanatory. The result was immediately telegraphed to Doctor Gatchalian and relayed to Doctor de Guia at the Bongabong Stock Farm in order that proper control measures may be taken at once.

GENERAL VACCINATION

In view of the proximity of the buffalo herd to the cattle herds, and in order to avert a rapid extension of the outbreak, general vaccination with hæmorrhagic septicæmia vaccine prepared by the method of the writer as described in 1935(2) was immediately ordered. Specimens of a grade Indian buffalo steer and pure-bred buffalo bull are shown in Plate 2, figs. 1 and 2. Of 1,589 animals vaccinated in the farm, 150 were buffaloes, 1,432 Nellore and grade cattle, and 90 were work carabaos of tenants and private persons. Fourteen buffaloes in all had already died when vaccination was begun, and only

one buffalo calf 10 months old died 48 hours after vaccination. In this particular animal it was presumed that infection had already set in when the vaccine was administered.

In view of the extreme susceptibility of buffaloes to *Pasteurella* infection, the herd was revaccinated five days after the first injection in order to insure absolute protection. After the general vaccination of all the animals, no more cases appeared, and up to the present writing everything is quiet on the farm.

ISOLATION AND IDENTIFICATION OF THE ORGANISMS

As described in the foregoing paragraphs, considerable difficulty was encountered in the microscopic diagnosis of the smear specimens submitted from the field, where successive examinations also proved negative. This difficulty is a common experience in some laboratories. In some instances even the isolation of the organisms by cultural and animal inoculations has completely failed. A case in point is the report of the writer in "An atypical case of hæmorrhagic septicæmia in the carabao" published in the Bureau of Animal Industry Gazette in 1931.(3) In the present outbreak the last specimen from which the organism was isolated by direct animal inoculation of blood and spleen was negative by microscopic examination, and yet the rabbits, guinea pigs, rats, and mice which received separate injections of blood and spleen emulsion all died in less than 17 hours, showing large numbers of organisms in the blood. Cultures in broth and agar slants from these dead animals contained abundant typical growths of *Pasteurella bipolaris bubalisepticus*. The organisms were nonmotile and Gram-negative, showing the characteristic bipolar staining. (Plate 1.)

Reaction in sugar media.—In dextrose there was acid and no gas; in maltose there was acid and no gas; in inositol, no reaction; in xylose, no change. This finding is characteristic of the group, although it is admitted that variations do occur.

Pathogenicity.—Broth cultures 24 hours old killed in 12 hours rabbits injected with 0.1 cc subcutaneously. The point of injection was hæmorrhagic, and there were no visible lesions in the organs except congestions which characterize high virulence and toxicity.

ORIGIN OF INFECTION

Because the Cabanatuan-Bongabong highway runs through the middle of the stock farm, and in spite of the complete fencing off of the pastures, the origin of infection is difficult to determine. Under the circumstances the following may be considered as having a bearing on the present outbreak. (1) A carabao of the many tenants may have become sick and died inside the farm without the matter having been reported to the superintendent. (2) Portions of infected carcasses may have been carried into the farm by dogs and other animals. (3) The abrupt changes from dry to rainy weather may have activated the organisms in the wallows or soil or in the animals themselves and caused disease. (4) Some other indirect source of contamination may have entered from outside the farm. Although there was no outbreak of septicæmia in the immediate vicinity of the farm at the time, it must be borne in mind that the disease is known to be enzoötic in Nueva Ecija.

SUMMARY

1. An outbreak of hæmorrhagic septicæmia in Indian buffaloes in this country has been described and reported for the first time.

2. It has been shown that in this disease repeated microscopic examination of fixed blood or spleen smears from acute field cases of septicæmia cannot be entirely relied upon as a method of diagnosis.

3. Often even the isolation of the organisms from a carcass by cultural methods and animal inoculation fails.

4. In the outbreak herein reported, in cases where the organisms were isolated by animal inoculation from the blood and spleen specimens, the ordinary smears from these materials were entirely negative on microscopic examination.

5. General vaccination, accompanied by disinfection of wallows and quarantine proved effective means of stopping the outbreak.

6. Of 1,589 animals vaccinated only one died forty-eight hours after injection; this animal may have been infected previous to injection.

ACKNOWLEDGMENT

For their coöperation in conducting the investigation of this outbreak, the writer is indebted to Drs. Pedro de Guia, Angel C. Dizon, A. B. Coronel, Miguel Muñoz, and Ventura Gatchalian, and to Dr. Elpidio Isip, Director of the Provincial Hospital of Nueva Ecija.

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3. TOPACIO, T. An atypical case of hemorrhagic septicemia in the carabao. *Bur. An. Industry Gazette* (10) 1 (1931) 13.

ILLUSTRATIONS

[Photomicrograph by the author; Winkel-Zeiss microphotographic apparatus; Carl Zeiss microscope, oil immersion; No. 10 ocular, apochromat H190 objective.]

PLATE 1

Heart-blood smear from a rabbit injected with blood from a 10-month-old calf which died June 23, 1938. *p*, organisms of hæmorrhagic septicæmia (*Pasteurella bipolaris bubalosepticus*).

PLATE 2

FIG. 1. A Grade Indian buffalo steer.
2. Pure-bred Indian buffalo bull.

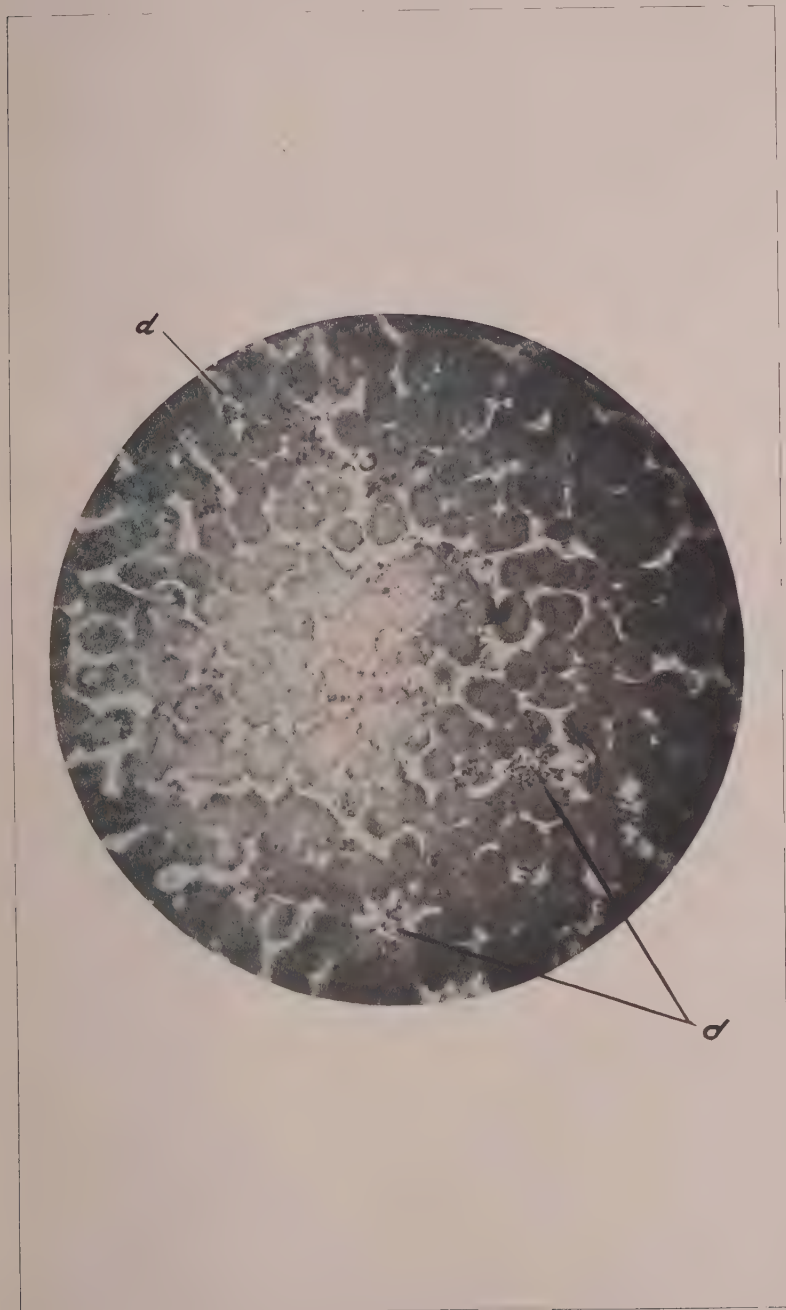


PLATE 1.



1



2

SOME NOTES ON THE UTILIZATION OF PHILIPPINE LOW-GRADE CHROMITE¹

By V. G. LAVA

Of the Division of Chemical Research, Bureau of Science, Manila

In another article² the optimum conditions in the roasting of Masinloc chromite for the manufacture of sodium bichromate were reported. The present article has to do with the preliminary experiments on the smelting of this ore and on its treatment with gases, with a view to increasing the chromium content of some of the resulting products.

Intensive concentration experiments with tabling, froth flotation, and electromagnetic methods conclusively point to the fairly homogeneous nature of the ore and to the impossibility of concentrating it by mechanical methods to a chromic oxide content of more than 39 per cent. Accordingly, attention was next centered on the direct smelting of the unconcentrated ore, and on its treatment with gases at high temperatures for its consequent break-up and partial separation into fractions of different chromium: iron ratios.

Experiments on the smelting of Masinloc chromite in the electric furnace.—For the purpose of experiments on the smelting of Masinloc chromite in an electric furnace, a crude furnace of magnesite brick with internal dimensions of 6 inches by 4 inches by 6 inches was constructed. The electrodes used were of 2-inch round carbon. For power, the direct current of the Bureau of Science was used; in order to regulate the current in the furnace, lead plates, immersed in a salt solution, were connected in series to the furnace, and one of the plates raised or lowered, depending upon the power necessary to bring the mixture to a melt.

The analyses of the chromite and reagents used are given in Table 1.

¹ Published with the permission of Mr. V. Elicaño, Technical Director and Vice-President of the Consolidated Mines, Incorporated, Manila. Read before the Fifth Philippine Science Convention, February 23, 1939. Received for publication, March 21, 1939.

² Philip. Journ. Sci. 69 (1939) 197.

TABLE 1.—Analyses of reagents used in smelting.^a

Constituents.	Chromite.	Lime.	Coke.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
SiO ₂	5.6	0.1	4.9
Al ₂ O ₃	26.2		1.8
Fe ₂ O ₃	(17.9)	0.2	2.2
FeO.....	16.5		
Cr ₂ O ₃	33.5	Nil	Nil
CaO.....	Trace	91.5	Trace
MgO.....	16.8	Trace	Trace
Volatile combustible matter.....			6.8
Fixed carbon.....			83.8

^a Fluorspar was not analyzed.

The smelting procedure consisted in dumping the mixture of ground chromite, flux, reducing agent, and fluorspar into the small furnace and heating by passing the current through the carbon electrodes which were covered by the mixture. No preheating was done. As soon as the mixture was completely melted, the hole at the bottom was opened, the electrical circuit opened, and the furnace tilted to pour out the melted mass. In some cases it was necessary to tear the furnace apart in order to take out the unattacked ore, reagents, and slag which contained a portion of the reduced metal.

Table 2 gives the results of smelting with variations in the percentages of lime and coke. It appears from this table that the optimum mixture of chromite, lime, and coke, with the use of 0.11 per cent fluorspar, is 1:0.20–0.30:0.25–0.30, or more specifically, 1:0.23:0.28. The ferrochrome produced is of commercial grade, and the impurities in it are not all carbon, analysis showing that the carbon content of the metal is about 1 to 3 per cent less than the total impurities.

The energy consumption per kilo of ferrochrome appears high,³ but it must be pointed out that no preheating was done, that no attempt was made to decrease heat loss through radiation, and that the method of charging was such that the whole field of reaction in the furnace was not utilized. Furthermore, in none of the experiments could a voltage of 50 or less be used, due to the limitations of the ammeter used, so that energy losses

³ See P. Bogetch, *Compt. rend.* (1933) 197, 1417–1419; D. A. Lyon, R. M. Keeney, and J. P. Cullen, *The Electric Furnace in Metallurgical Work*, U. S. Gov't Printing Office, Washington (1916) 127–141; Volianisk, *Journ. pour Elec.* (1934) 43, 90, 91.

TABLE 2.—Effects of different amounts of lime and coke on the smelting of Masinloc chromite.

[1000 grams chromite were used per charge.]

[Fluorspar, 11 grams.]

Experiment.	Coke. g.	Lime. g.	Power. kw.	Charging time. Hours.	Extraction. Per cent.	Chromium in metal. Per cent.	Iron in metal. Per cent.	Impurities. Per cent.	Remarks.
1.	150	150	9.0	0.6	28	61.5	30.0	8.5	No fusion.
2.	250	150	10.0	1.2	83	58.4	32.4	9.2	Difficult to obtain fluid slag.
3.	300	150	10.0	1.2	83	58.4	32.4	9.2	Very viscous slag.
4.	150	200	6.6	1.0	83	59.6	34.6	5.8	Difficult to melt slag.
5.	250	200	6.5	1.0	93	63.2	30.4	6.4	Fluid slag at 8 kw.; porous metal.
6.	300	200	7.7	1.4	106	56.8	28.4	14.8	Fluid slag at 8.5 kw.; carbide odor.
7.	350	200	6.8	1.4	64	60.0	33.7	6.3	Very viscous slag.
8.	150	300	5.0	1.2	53	54.8	40.0	5.2	Fluid slag; porous metal.
9.	250	300	4.8	2.0	94	59.3	30.5	10.2	Fluid slag around 5.5 kw.
10.	300	300	5.7	1.8	99	58.4	30.6	11.0	Fluid slag.
11.	360	300	7.0	1.9	86	58.6	31.8	9.6	Fluid slag at 8 kw.
12.	150	375	6.2	1.0	58	56.8	37.9	5.3	Fluid slag at 10 kw.
13.	250	375	6.5	1.4	81	60.0	31.1	8.9	Fluid slag at 8.4 kw.
14.	300	375	6.1	1.8	99	58.4	29.3	12.3	Fluid slag at 6.6 kw.
15.	360	375	6.1	1.5	95	58.6	32.3	9.1	Fluid slag at 8.6 kw.

were high. For a fairly accurate determination of energy consumption per kilogram of ferrochrome, a semicommercial furnace would be necessary, or at least one with an automatic arrangement for maintaining current flow.

As long as power is cheap, and since with the Udy⁴ process ore with as low as 18 per cent chromic oxide can be commercially treated, power consumption should not be a deterrent factor for the utilization of Masinloc chromite.⁵

Experiments on the chlorination of Masinloc chromite.—Besides mechanical treatment, various methods have been proposed to increase the Cr:Fe ratio of the ore for the manufacture of ferrochrome. These methods apply to either low-grade chromite or ferrochrome low in chromium.

British Patent 176,729 (1920) proposes the crushing and washing of chromite and treatment at 900°C. with a mixture of HCl and H₂. In this way ferric chloride is volatilized; and by afterwards raising the temperature of the furnace to 1,200°C. and passing Cl₂ over the residue, the chromic chloride is volatilized separately and can be further treated for smelting purposes.

British Patent 269,029 (1926) starts with ferrochrome and calls for the use of Cl₂ or gases containing chlorine to attack the metal, the heat produced after the reaction starts being sufficient to maintain the reaction. In this way the iron chloride sublimates at one end of the furnace, while the chromium chloride may be continuously withdrawn at the other end. Small quantities of reducing agent, such as CO with Cl₂ or carbon, may be mixed with the ferrochrome.

In British Patent 305,712 (1927), chromium ores are given preliminary "opening up" treatment by heating and quenching in water or by melting with 5 per cent or more of an alkali reagent in a nonoxidizing atmosphere. The mixture is then treated at 500° to 600°C. with HCl or Cl₂ or both, with or without reducing agents. In this way there is left a residue of either the chloride or oxide of chromium, depending on the gas used.

British Patent 256,433 (1925) does not use chlorine compounds, but increases the chromium content of the metal by

⁴ Udy, Marvin J., British Patent 437,008, Oct. 22, 1935; Canada Patent 357,274, April 21, 1936.

⁵ Personal information has been obtained from Mr. V. Elicaño that Masinloc chromite has been successfully used with the Udy process on a commercial scale in the United States.

decreasing its carbon content. In this patent the ore is mixed with an oxygen-containing sodium compound and carbon, and the mixture is smelted in a blast furnace. Any chromium carbide formed is decomposed by introduction of sodium chromate through the truyeres.

Our experiments with Masinloc chromite make use of chlorine, hydrogen chloride, or both, and coconut charcoal as the reducing agent. The reaction was carried out in a long silica tube heated by an electric furnace. The gases were first dried in H_2SO_4 before they were allowed contact with the mixture of ore and carbon. Table 3 shows the results of concentration of the ore with HCl and Cl_2 gases, and the effect of temperature on the extent of the reaction and ease of separation.

In experiments 1 to 7 chlorine gas alone was used, and in experiments 8, 10, 11, and 12, hydrogen chloride alone. In experiment 9 a mixture of chlorine and HCl was used, and in experiment 13, HCl alone, followed by chlorine alone.

The products of concentration when chlorine is used may be conveniently divided into four fractions; (1) distillate remaining in the glass tube outside the silica tube; (2) distillate remaining at the end of the silica tube; (3) distillate mostly of CrCl_3 and FeCl_3 , which remains nearest the residue and is pink; and (4) the gray residue which is in the form of cakes. Part of the chloride distillate is absorbed in the alkali bottle after the glass-tube fraction. With the use of HCl gas no division into the above fractions is noted; instead there is a slight amount of distillate in fractions 1 and 2, but most of the substance is in the residual fraction.

Experiments 1 to 4 show that when chlorine gas is used alone some chromium is lost to fractions 1 and 2 in the form of chloride, and the greater the amount of reducing agent used the greater the loss of chromium in fractions 3 and 4. Also, for the same ratio of chromite to carbon (experiments 5 to 7), the lower the temperature, the greater the amount of iron recovered in fractions 3 and 4. In experiment 7 the temperature is so low that the carbon was hardly attacked.

When HCl is used, for the same mixture of chromite and carbon (experiments 8, 10, 11, and 12), the higher the temperature the greater the recovery of chromium in the residue; while the iron recoveries are also fairly high, though lower than those for chromium.

TABLE 3.—Chlorination of Masinloc chromite.*

Experiment.	Carbon.	Furnace temperature, °C.	Preheating time, Min.	Apparent reaction time, Hours.	Gases used.	No. of bubbles per second	Products.							
							Fraction 1.				Fraction 2.			
							Weight.	Cr.	Fe.	Cr: Fe.	Weight.	Cr.	Fe.	Cr: Fe.
1	<i>p.</i>	700	45	1	Cl	3.3	<i>g.</i>	Per cent.	Per cent.		<i>g.</i>	Per cent.	Per cent.	
2	1.2	700	45	1	Cl	3.0	0.52	10.0	6.0	1.7	3.18	10.0	7.9	1.3
3	0.8	700	45	1	Cl	3.0	0.40	11.5	10.4	1.1	1.81	8.9	8.9	1.0
4	0.4	700	45	1	Cl	3.0	0.25	3.6	14.5	0.25	1.07	12.5	10.5	1.2
5	0.0	700	45	1	Cl	3.0	0.02							
6	0.72	700	45	1	Cl	2.7	0.23							
7	0.72	680	45	1	Cl	2.7	0.10				0.95	8.3	9.3	0.9
8	0.72	570	45	1	Cl	2.7					1.62	1.2	12.3	0.1
9	0.72	680	45	1	HCl	2.5					0.40	5.7	18.0	0.3
10	0.72	680	45	1	HCl & Cl	3.0								
11	0.72	700	45	1	HCl	2.5					1.40	6.4	11.3	0.6
12	0.72	770	45	1	HCl	3.0					0.07			
13	0.72	830	15	1	HCl	3.0								
	0.72	680	30	0.5 & 0.5	HCl & Cl	3.0					0.34			

Experiment.	Products.										Recovery of metal. ^b				Cr: Fe in fractions 3 and 4.	
	Fraction 3.					Fraction 4.					Cr in fractions 1 and 2.	Fe in fractions 1 and 2.	Cr in fractions 3 and 4.	Fe in fractions 3 and 4.		Cr: Fe in fractions 1 and 2.
	Weight.	Cr.	Fe.		Cr: Fe.	Weight.	Cr.	Fe.		Cr: Fe.						
			Per cent.	Per cent.				Per cent.	Per cent.							
1.....	g.	1.22	18.6	7.3	2.6	2.05	5.1	1.4	3.5	41	57	37	35	1.3	1.91	
2.....	1.60	16.0	11.0	1.5	2.76	14.1	3.1	4.6	23	41	72	52	1.0	2.47		
3.....	1.18	11.5	14.8	0.8	3.05	21.0	3.8	5.6	15	30	85	55	1.0	2.84		
4.....	0.12				3.68	24.7	8.3	3.0				96	60		2.96	
5.....	2.14	10.7	1.5	7.1	2.80	21.5	6.7	3.2	9	18	91	44	0.9	3.77		
6.....	0.15				3.57	13.1	6.4	3.0	2	40	71	45	0.1	2.86		
7.....					5.45	16.2	7.9	2.1	3	14	95	86	0.3	2.06		
8.....					3.61	21.8	9.7	2.3			87	70		2.26		
9.....	0.60	10.8	12.1	0.9	3.25	19.4	5.0	3.9	10	28	77	47	0.5	2.96		
10.....					3.57	23.7	9.0	2.6			93	62		2.62		
11.....					3.75	23.5	10.5	2.3			97	89		2.25		
12.....					3.78	24.3	11.1	2.2			100	84		2.18		
13.....					3.65	21.5	9.3	2.3			87	68		2.32		

^b Based on original chromite.^a 4 grams were used.

The ratios of metallic chromium and iron are calculated for the combined fractions 3 and 4. In the original chromite this ratio is 1.8; and it is clear that in all the experiments there was an increase in the ratio in the combined fractions 3 and 4, varying from 1.9 to 3.8. When we consider that for a ferrochrome of the composition $\text{Cr} : \text{Fe} : \text{C} = 70 : 25 : 5$, the ratio of Cr to Fe is 3, while for an alloy of composition $\text{Cr} : \text{Fe} : \text{C} = 68 : 27 : 5$, the ratio of Cr to Fe is 2.5, it is clear that such compositions of ferrochrome may be obtained by heating chromite with or without carbon and passing either chlorine gas alone or HCl alone or a mixture of the two, at a fairly high temperature.

SUMMARY AND RECOMMENDATIONS

1. Preliminary experiments on the smelting of low-grade Masinloc chromite show that commercial ferrochrome may be obtained from this ore, and that the optimum mixture of chromite:lime:coke is around 1:0.23:0.28. In order to show the competitive position and the actual value of the Masinloc chromite reserve, it will be necessary to carry on in the Philippines further smelting experiments on a semicommercial scale, especially with the use of the Udy process.

2. Preliminary experiments on the chlorination of Masinloc chromite further indicate that certain fractions of chlorination are obtained which yield a ratio of Cr:Fe higher than 2.5, thus ensuring an even higher ratio of Cr:Fe in the production of ferrochrome. Chlorination without carbon shows good possibilities.

CHEMICAL ANALYSIS AND VITAMIN ASSAYS OF OPIHI, THE HAWAIIAN LIMPET¹

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ONE PLATE AND ONE TEXT FIGURE

There is little or no scientific information available regarding the nutritive value of the many mollusks and crustaceans formerly used as food by the Polynesians in the Pacific, and still used, to a greater or less extent, by groups depending on the sea for an important part of their sustenance.

The opihi, or Hawaiian limpet, was one of the favorite shellfishes of the ancient Hawaiians. The natives have names for a number of varieties and sizes of opihi, although only two, *Helcioniscus exaratus* Nuttall and *H. argentatus* Sowerby, have been given scientific names, apparently on the basis of shell shapes. There seem to be intermediate shapes that cannot always be clearly distinguished even by scientists.

According to our Hawaiian informants, opihi were formerly found on all the islands the year round and eaten by all classes of people. The soft parts of the opihi mixed with *poi*³ constituted one of the first foods fed to Hawaiian infants in addition to mother's milk in olden days. Opihi are usually eaten raw, either fresh or salted, frequently with certain seaweeds; they are sometimes cooked, but in this form are tougher than raw. Ethnologists state that in olden days opihi for use as food were taken inland distance requiring several days' travel, as evidenced by the opihi shells found in caves on the slopes of Mauna Kea and Mauna Loa mountains on the island of Hawaii, and in the crater of Haleakala on Maui. They have recently

¹Published with the approval of the Director of the Hawaii Agricultural Experiment Station. Since the above article was written, Mr. M. E. Nelson and Dr. S. S. Ballard, of the Physics Department of the University of Hawaii, have shown by spectrographic methods that the vitamin A activity of the hepato-pancreas of the opihi is due entirely to carotene. The characteristic absorption band of vitamin A could not be detected, whereas the β -carotene bands were prominent.

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³A smooth paste made by cooking, grinding, and pounding corms of taro (*Colocasia esculenta*).

been found, along with kukui shells, in some of the bubble caves on Mauna Kea at an elevation of about 12,500 feet.⁽¹³⁾

Opihi can usually be bought on the Honolulu markets today, but they have become a luxury, selling at for 25 to 30 cents per pound in the shells. Approximately 35 per cent of the mollusk is edible, so that the edible portion costs approximately 80 cents per pound.

The nutritive value of two Mollusca of the Lamellibranchia class, oysters and clams, has been investigated in recent years, but no work has been reported on the Gastropoda, the class to which the opihi belong. The studies herein reported were undertaken to determine the various nutritive elements of this shellfish.

CHEMICAL ANALYSIS OF OPIHI

Methods.—The methods employed in the determination of the organic nutrients were those of the Association of Official Agricultural Chemists,⁽²⁾ with the following exceptions: glycogen was determined by two methods explained hereafter; calcium by the McCrudden volumetric method;⁽¹⁷⁾ iron by the method of Elvehjem and Hart;⁽¹¹⁾ and copper by the method recommended by Elvehjem and Lindow⁽¹²⁾ for materials rich in iron. For the iron analyses precautions taken to prevent contamination included avoiding the use of iron utensils, ashing the material without previous drying, and subtracting the iron value of a blank determination run simultaneously. Copper determinations were guarded in a similar manner.

All analyses, except those for glycogen, were made on opihi bought at the local retail fish market. The opihi were, for the most part, alive when prepared for analysis; but, as they were shipped to Honolulu from the nearby islands, they had been out of their natural habitat for 24 hours or longer. The analyses given in Table 1 for the two portions, foot and mantle, and the viscera of the opihi were made on a composite sample prepared from about 7 pounds⁴ of opihi in the shell, 1,220 grams of edible portion. The foot and mantle, constituting the tougher portion of the shellfish, and the viscera or soft parts, including the digestive tract, hepatopancreas, and gonad, were analyzed separately, and the composition of the whole was calculated from the proportion of each, which made up the original material. The composition of the whole thus calculated agrees almost exactly with analyses made on two separate samples of whole

⁴ 3.2 kilograms.

opihi at intervals of several years. It is, therefore, believed that the figures in Table 1 represent satisfactory averages for the composition of whole opihi.

Samples of live opihi purchased at the fish market in Honolulu and of opihi taken directly from the rocks in the ocean were analyzed for glycogen by two methods—Carruthers(7) and the modified method given by the Association of Official Agricultural Chemists.(2) In order to prevent changes in the glycogen content after removal from the rocks, the opihi were immediately shelled, weighed, and placed in boiling water for the Carruthers method or in potassium hydroxide solution for the Association of Official Agricultural Chemists' method; the analyses were completed later at the laboratory. After extraction and hydrolysis of the glycogen, the resulting glucose was determined, first by the Allihn gravimetric method and then by the volumetric thiosulfate method.(2)

Results.—The figures for the chemical composition of opihi given in Table 1, as compared with those reported for other shellfish,(20) indicate that the percentage of protein in whole opihi is greater than in clams, and much greater than in oysters or mussels; all of these shellfish are low in fat, of which they have less than 2 per cent. Opihi are a better source of calcium, phosphorus, and iron than are clams or oysters, but the quantity of copper in opihi is smaller than that reported for oysters.(16) Table 1 shows that the viscera, commonly spoken of as the soft parts of the opihi, contain relatively greater percentages of fat, calcium, phosphorus, and iron than does the foot and mantle portion. Opihi, like most products of the sea, are a good source of iodine(4) containing 4,480 parts per billion of the dried material, or about 1,050 parts per billion of average fresh material.

The analyses of opihi for glycogen, summarized in Table 2, show that the Carruthers method was not satisfactory for the extraction of this substance from the tough foot and mantle. By the Association of Official Agricultural Chemists' method, involving potassium hydroxide solution which caused disintegration of the tissue, the foot was shown to have a much greater percentage of glycogen than the viscera. The total quantity of glycogen in the whole opihi taken directly from the sea did not vary greatly from that of live animals from the market which had been out of the water for some time. Whole opihi contain about 1 per cent of glycogen, a quantity one-third to one-fourth that found in such sea foods as abalone, mussels, and oysters.(20)

TABLE 1.—*Chemical composition of opihi expressed as per cent of fresh edible material.*

Part.	Moisture.	Protein (N x 6.25).	Ether extract.	Ash.
Foot and mantle.....	77.8	18.8	0.3	1.52
Viscera (total soft parts).....	73.3	13.3	5.5	4.05
Whole ^a	76.6	17.3	1.7	2.21
Viscera without gonads.....	75.5	12.0	1.6	4.60
Ovaries.....	62.6	23.9	8.7	1.74
Testes.....	76.0	20.0	2.2	2.45

Part.	Calcium.	Phos- phorus.	Iron.	Copper.	Silicon.
Foot and mantle.....	0.052	0.122	0.00204	0.00011	0.04
Viscera (total soft parts).....	0.698	0.211	0.04536	0.00008	0.28
Whole ^a	0.230	0.146	0.01395	0.00010	0.11
Viscera without gonads.....	1.174	0.163	-----	-----	0.16
Ovaries.....	-----	-----	-----	-----	-----
Testes.....	-----	-----	-----	-----	-----

^a Calculated from analyses of foot and mantle, and viscera given above (72.2 per cent foot and mantle, 27.5 per cent viscera).

TABLE 2.—*Glycogen content of opihi tissues expressed as per cent of fresh edible material.*

Method.	Source.	Whole.	Foot and mantle.	Viscera.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Carruthers.....	From market.....	^a 0.11	0.04	0.27
Do.....	From sea.....	0.13	0	0.18
Do.....	do.....	0.21	-----	-----
A. O. A. C. ^b	From market.....	^a 0.96	1.27	0.22
Do.....	From sea.....	^a 1.00	1.23	0.47
Do.....	do.....	1.11	-----	-----
Do.....	do.....	1.02	-----	-----

^a Calculated from analyses of foot and viscera (70 per cent foot, 30 per cent viscera).

^b Association of Official Agricultural Chemists.

THE VALUE OF THE OPIHI FOR HÆMOGLOBIN REGENERATION

Whipple and Robschey-Robbins(26) have shown fish liver and whole fish to be almost inert for hæmoglobin regeneration in dogs, whereas mammalian liver is very potent. On the other hand, Levine, Remington, and Culp(16) have found oysters to be effective in curing nutritional anæmia in the rat. An experiment to investigate the hæmoglobin regenerating value of another shellfish, the opihi, is reported below.

Nutritional anæmia was produced in 55 young albino rats by a diet exclusively of milk. The methods of feeding and blood

sampling have been previously reported.⁽¹⁴⁾ The results of experiments with anæmic rats fed opihi supplements with and without added iron or copper are summarized in Table 3. Daily supplements of 4 grams of whole opihi for 55 days resulted in considerable increase in weight but poor regeneration of hæmoglobin. Daily supplements of 4 grams of whole opihi plus iron for 19 days had little or no value in regenerating hæmoglobin, but when 0.01 milligram of copper, in the form of a basic copper-sulphate solution, plus 4 grams or even 2 grams of opihi were fed daily, the hæmoglobin reached almost normal levels after about 8 weeks. Chemical analyses of whole opihi reported in Table 1 show that this shellfish contains a relatively large percentage of iron but a small percentage of copper. It is, therefore, not surprising that the addition of even minute amounts of copper to the opihi supplements resulted in good hæmoglobin regeneration, whereas the addition of iron in the form of ferric chloride had no significant effect.

TABLE 3.—Hæmoglobin regeneration in anæmic rats fed opihi.

Kind and quantity of supplement fed daily.	Number of rats.	Days supplement was fed.	Average weight of rats.		Average hæmoglobin.		Relation of spleen weight to total weight.
			When started on supplement.	Final.	When started on supplement.	Final.	
None (control).....	7	-----	g.	g.	g.	g.	Per cent.
Iron, 0.5 milligram.....	5	40	67	65	3.4	2.7	0.32
Iron, 0.5 milligram.....	5	40	64	83	4.2	4.7	0.33
Opihi, 4 grams.....	28	55	86	131	4.2	6.1	^a 0.59
Opihi, 4 grams.....	8	19	^b 104	117	3.6	3.8	-----
Iron, 0.5 milligram.....							
Opihi, 4 grams.....	8	59	62	184	3.8	12.1	0.32
Copper, 0.01 milligram.....							
Opihi, 2 grams.....	4	53	59	168	4.1	12.1	0.31
Copper, 0.01 milligram.....							

^a Average of 26 rats, 2 rats having died and their spleens not having been weighed.

^b Weight when iron supplement was started. Rats have been fed opihi supplements for 4 weeks previously, which resulted in gains in weight but not in hæmoglobin regeneration.

The enlarged spleens found at autopsy in anæmic rats fed opihi without other supplements have been found in all anæmic rats at that period of recovery when the hæmoglobin reaches a level of about 6 to 8 grams per 100 ml of blood. Detailed studies of this work have been reported elsewhere.⁽¹⁴⁾

VITAMIN VALUE OF OPIHI

The methods used for the determination of the vitamin contents of opihi were essentially those recommended by Sherman,(19) and except for vitamin D have been fully described elsewhere.(18) The international standards were used for the vitamin A and part of the vitamin D tests, but were not available at the time the vitamin B and vitamin C tests were made. For the vitamin B₂ (G) tests an extract of tikitiki was used to supply vitamin B₁ instead of the alcoholic extract of whole wheat recommended by Bourquin and Sherman.(6)

To prepare the whole opihi for feeding, the radulæ were discarded, the viscera were separated and placed in a beaker, and the foot and mantle portion was finely minced with a board and knife used solely for that purpose. The minced material was then intimately mixed with the viscera. The viscera, without gonads, consisting mostly of digestive tract and hepatopancreas, were freed of a bit of membranous material and made into a homogenous mixture. The small feedings given twice a week were accurately and quickly weighed on tared watch glasses and immediately fed to the rats which ate all the opihi and licked the glasses clean.

VITAMIN A

Experimental.—Two hundred eighteen rats were used to determine the vitamin A value of opihi. The kind and quantities of supplements fed are listed in Table 4.

The carotene was carefully prepared from the international standard involving the use of purified cottonseed oil through which dry carbon dioxide had been bubbled for 3 hours. The cottonseed oil had been proved by feeding tests to be without vitamin A activity. The supply of prepared carotene was kept in the dark in small vials in an atmosphere of carbon dioxide at about 0°C. Not more than 1 week's supply was transferred to an electric refrigerator at a time, and the amount used each day was removed as needed. The carotene was fed by calibrated pipettes 3 times per week.

For vitamin A experiments we find it impossible to keep rats in good condition and have most of them survive the experimental feeding period, unless the gains in body weight are relatively large. The rats in series 1, 2, and 3 were all 3 weeks of age when placed on the diet and, as shown in Table 4, averaged about 40 grams in weight. However, their average weight

TABLE 4.—Results of feeding various amounts of opihi to rats as the sole source of vitamin A.

Supplements.	Number of rats.	Supplement fed weekly.	Average weight.			Average gain in six weeks.
			Initial.	When supplement started.	Final.	
FIRST SERIES						
Negative control.....	15		g. 40	^a 124	g. 87	g.
International standard, carotene.....	4	18 units.....	41	107	156	49
Do.....	9	24 units.....	43	126	214	88
Opihi, whole.....	10	0.3 gram.....	40	110	163	53
Do.....	7	0.4 gram.....	42	124	201	77
Opihi, foot.....	6	1.0 gram.....	40	141	178	37
Do.....	12	2.0 grams.....	40	128	192	65
Opihi, viscera without gonads.....	15	0.05 gram.....	40	134	183	49
Do.....	9	0.1 gram.....	42	119	175	^b 56
Opihi, ovaries.....	10	0.2 gram.....	41	126	201	75
Opihi, testes.....	13	0.1 gram.....	39	120	175	55
SECOND SERIES						
Negative control.....	5		40	^a 126	90	
International standard, carotene.....	11	24 units.....	41	130	234	104
Opihi, whole.....	9	0.4 gram.....	41	124	219	95
Opihi, viscera without gonads.....	7	0.05 gram.....	38	126	201	75
THIRD SERIES						
Negative control.....	4		46	^a 170	107	
International standard, carotene.....	4	24 units.....	41	128	229	101
Opihi, whole.....	7	0.5 gram.....	42	142	241	99
Opihi, viscera without gonads.....	6	0.08 gram.....	43	133	222	89
FOURTH SERIES						
Negative control.....	7		33	^a 82	82	(b)
International standard, carotene.....	12	6 units.....	32	79	157	^b 78
Do.....	12	12 units.....	33	79	178	^b 99
Opihi, whole.....	12	0.3 gram.....	30	77	174	^b 97
Do.....	12	0.5 gram.....	31	81	194	^b 113

^a Weight at end of the depletion period.^b Fed for five weeks only.

was usually well above 100 grams before they showed plateauing or loss of weight. The results of the experiments listed under series 1, 2, and 3, which were completed 4 years previously, might be criticized as not showing sufficient refinement of method, both because of the large gains in weight during the feeding period and because the number of rats fed the standard was not always equal to the number fed the substance tested. A fourth series of experiments was therefore conducted.

The vitamin A stores of the experimental animals in series 4 were reduced by changing the good breeding diet of the mothers to a diet of skim milk and ground whole wheat one week after

the young were born; this low vitamin A diet was the only one to which the young rats had access before they were placed at 3 weeks of age on the vitamin A-free diet previously described.⁽¹⁸⁾ On the vitamin A-free diet such rats react quite uniformly; they gain rapidly for about 3 weeks and then the weight drops. If the rats are continued on the vitamin A-free diet, xerophthalmia invariably appears along with other signs of vitamin A deficiency—lung, kidney, and bladder infections, pus at the base of the tongue, and injury to the nerves which causes dragging of the hind legs. If the weights of the rats are allowed to become stationary or drop slightly before the feeding of supplements is begun, a large proportion of the rats show serious infections and may succumb before the end of the experimental period. For series 4, therefore, 7 litters of rats, prepared as indicated above, were placed on the vitamin A-free diet; after 2 weeks one rat from each litter was selected as a negative control and the remainder were divided into four groups fed supplements as follows: 1 unit international standard carotene daily or 6 units weekly; 2 units daily or 12 units weekly; 0.3 gram whole opihī weekly; and 0.5 gram whole opihī weekly. Care was taken to divide the litters in such a way that each group contained the same number of rats of each sex and of about the same weight. Except for the control group, which contained 5 males and 2 females, each group of 12 rats comprised 5 males and 7 females.

As can be seen from text fig. 1, all groups of rats showed equally rapid growth during the first week, after which the weights of the negative controls dropped while those of the other rats receiving the supplements continued to increase. Starting the supplement feeding before complete depletion of the vitamin A stores kept the rats in good condition, so that those receiving the smallest quantity of vitamin A from the supplements lived out the experimental period of five weeks without showing many signs of deficiency, as rats in our colony do when depleted of vitamin A stores until the growth curve drops or plateaus and then are fed 1 unit of vitamin A for 6 days a week.

In addition to the above experiments, 55 rats were used for the 1-feeding method recommended by Sherman and Todhunter.⁽²²⁾ The results were unsatisfactory, because the growth response and period of survival were not increased in proper

proportion as the quantity of supplement was increased; they are, therefore, not reported here.

Data and discussion.—From the data presented on the first three series (Table 4) one may conclude that whole opihi contain 4,500 to 5,000 units of vitamin A per 100 grams of fresh material; that the foot and mantle portion of the opihi contain much less vitamin A than the viscera without gonads; and that the testes contain about the same quantity of vitamin A as the viscera without the gonads and a somewhat greater quantity of vitamin A than the ovaries.

Table 4 and text fig. 1 summarize the experimental data for the rats of series 4 which had smaller stores of vitamin A when placed on the vitamin A-free diet, but whose reserves of vitamin A were not exhausted before the supplements were started. The average curves of the 2 groups of rats fed 0.3 gram whole opihi weekly and 12 units of the vitamin A standard weekly coincide so closely that it is difficult to distinguish between them. Judging the vitamin A value on this basis, fresh whole opihi contain 40 units per gram or 4,000 international units per 100 grams instead of 4,500 to 5,000 units as shown by the first three series of experiments. The value of 4,000 per 100 grams compares favorably with that of 5,000 international units for average butter and egg yolk reported by Sherman (1932); however, many samples of these two foods show much lower values.⁽¹⁰⁾ Whole opihi contain an average of 76.6 per cent moisture; thus, moisture-free opihi would contain 17,000 international units per 100 grams, about one-tenth as much as good cod-liver oil. However, in the fresh state opihi may be considered an excellent natural food source of vitamin A and must have been an important source of this vitamin in the diet of the ancient Hawaiians.

VITAMIN B₁

To determine the vitamin B₁ content of opihi, 31 rats, weaned at 4 weeks of age and weighing 51 grams on the average, were placed on the vitamin B-free diet recommended by Sherman.⁽¹⁹⁾ After less than three weeks on this diet the vitamin B stores of the rats were exhausted when feeding of the opihi supplements was started. Twenty-three rats fed 4 grams of opihi daily sustained an average loss of 23 grams during an 8-week feeding period (Table 5). Four rats fed 6 grams daily gained an average of only 4 grams in 8 weeks. These results prove opihi to be a very poor source of vitamin B₁.

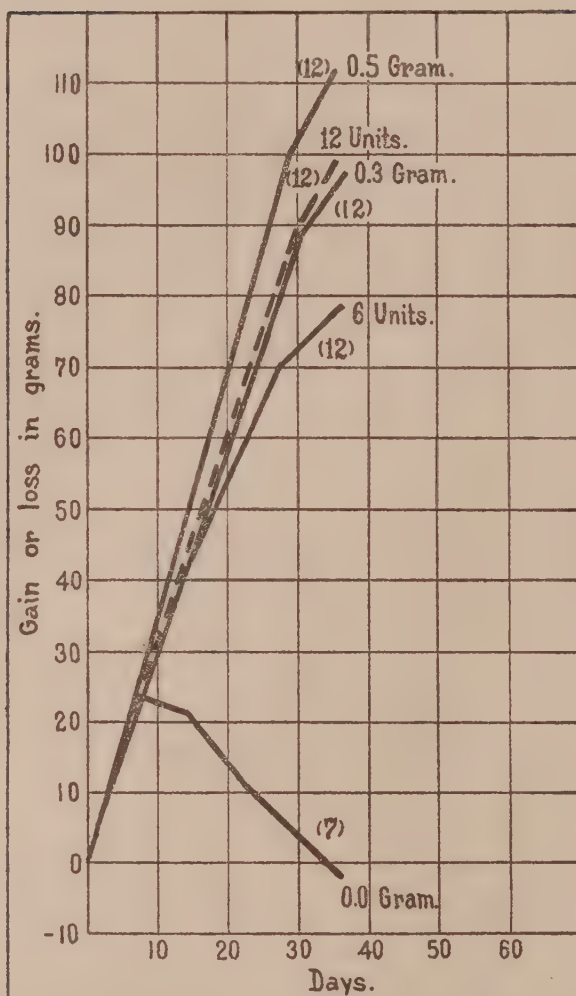


FIG. 1. Average gain in weight of groups of young rats fed opihl and the international standard carotene. The quantities indicated were fed weekly. The numbers in parentheses show the number of rats used for each test.

VITAMIN B₂

The Bourquin-Sherman⁽⁶⁾ method for determining the factor until recently called vitamin B₂ or G has been shown by a number of investigators to be a test for flavin.⁽³⁾ Unpublished results from this laboratory show that, when the other factors of

TABLE 5.—Results of feeding various amounts of opihi to rats as their sole source of vitamins B₁ and B₂ (G).

Vitamin studied and source.	Number of rats.	Weight of supplement fed daily.	Average weight.			Average gain or loss in 8 weeks.
			Initial.	When supplement started.	Final.	
Vitamin B ₁ :		g.	g.	g.	g.	g.
Negative control.....	4	0	52	^a 74	50	-----
Ophi, whole.....	23	4.0	51	74	51	-23
Do.....	4	6.0	48	68	72	+ 4
Vitamin B ₂ (G):						
Negative control.....	4	0	54	^a 78	75	+ 2
Ophi, whole.....	14	0.5	55	76	96	+20
Do.....	17	1.0	54	72	115	+43

^a Weight at end of depletion period.

the vitamin B complex are supplied by an extract of rice polishings, rats respond with increased increments of growth proportional to the quantities of pure flavin fed, up to 15 γ. The tests here recorded, made in 1931-1932, were, therefore, a test for flavin.

Thirty-five rats used in the experiment were placed on the Bourquin-Sherman vitamin G-free diet at 4 weeks of age, at which time they averaged 54 grams in weight. The weights remained almost stationary after 33 to 35 days on this diet, when feeding of opihi began. The results summarized in Table 5 show that 14 rats, fed 0.5 gram of whole opihi daily, gained an average of 20 grams in 8 weeks or 2.5 grams per week, and 17 rats fed 1 gram of opihi daily gained 43 grams in 8 weeks or 5.4 grams per week. The quantity of opihi that would permit the unit rate of gain of 3 grams per week must lie between 0.5 and 1 gram daily and would probably be less than 0.75 gram. Ophi, therefore, contain about 1.3 vitamin B₂ (G) units, or 2 to 2.5 γ flavin(3) per gram; or about 130 Sherman-Bourquin units, or 300 γ flavin per 100 grams. Ophi are at least as good a source of this factor as average lean beef and whole eggs, and are better than average milk. (10)

VITAMIN C

Seventeen standard young guinea pigs were fed Sherman's(19) scorbutic diet plus fresh alfalfa until 11 of them were induced to eat opihi. Two were then continued on the basal diet plus supplements of alfalfa and used as positive controls; four were fed on the basal diet or 21 days and served as negative controls;

seven were fed supplements of 2 grams of whole opihi daily; and four were fed 4 grams of opihi daily for 21 to 28 days.

The guinea pigs fed opihi and the negative controls showed equally severe gross scurvy at autopsy, and histological examination of the teeth of both groups showed no protection whatever. The positive controls were completely protected from gross scurvy and their teeth showed no histological changes. The conclusion may be drawn that opihi contain no demonstrable quantity of vitamin C. In order to save space, no protocols are given.

VITAMIN D

Experimental.—Two hundred and thirty-seven rats were used for the vitamin D experiments; 189 were fed supplements and the others were used as negative controls. Rats 28 or 29 days old and weighing, with few exceptions, between 55 and 60 grams, were given the Steenbock yellow corn ration No. 2965.⁽²³⁾

After 21 days one rat from each litter was killed and one was continued on the basal diet without supplement until the 29th day, both being considered negative controls. Beginning on the 21st day the other rats in each litter were fed various supplements for 8 days and were then killed the 29th day after the rickets-producing diet was begun. In the first experiments (series A), one or more rats of each litter, fed a good grade of commercial cod-liver oil, served as positive controls. After the international standard irradiated ergosterol and reference cod-liver oil were made available, further experiments (series B) were conducted, in which several rats from each litter were fed these supplements at two different levels. Near the beginning of the experiments, 5 litters of 52 rats of series A were used to compare the results of bone analyses with the results of the line test. The tibias were used for the line test and the femurs for the chemical analyses. The femurs were carefully removed and freed of all adhering material, weighed, and ashed as recommended by Sherman and Stiebeling.⁽²¹⁾ Total ash and calcium of the fresh femurs, and the percentage of calcium in the ash, were determined.

Five of the positive control rats in series A, fed a diet containing 1 per cent cod-liver oil, failed to gain in weight. As these positive controls without exception showed a 4+ healing they were not discarded. As one rat, fed 0.5 of a unit of the international standard per day, lost 4 grams in weight, his record was discarded. Bills et al.⁽⁵⁾ have warned against the use

of animals that fail to gain weight, as such a reaction may cause healing even when no curative supplement is given.

At autopsy both tibia were removed from each rat and preserved in 10 per cent formalin until the line test⁽⁵⁾ was applied. The bones were studied under a low-power binocular microscope, and the degrees of healing rated as recommended by Bills et al.: — (no healing), 1+, 2+, 3+, and 4+ (healing). Photographs were made of the line tests of about half the animals, and the degrees of healing exhibited in the photographs were compared with the ratings made directly from the bones.

Data and discussion.—The results of the chemical analyses of the femurs of 52 rats are summarized in Table 6. Although 3 grams of opihi per day induced, on the average, better than 3+ healing of rickets, and 4 grams almost 4+ healing, the quantity of ash or of calcium in the fresh femurs, or of calcium in the ash, bears no consistent relation to the degree of healing in comparison with the results for either the negative or the positive controls. In every case the supplements were fed for only 8 days, which may have been too short a period to influence the ash and calcium of the bones. No attempt was made to keep the food intake of all the rats similar. The average gains in body weight during the 8 days of supplementary feeding are similar for the various groups of rats fed whole opihi, the viscera, and the gonads, yet the total ash and calcium in the fresh femurs is greater for those that received the ovaries and testes than for those fed the other opihi supplements, and the total ash compares favorably with that of the rats in the cod-liver oil group. However, the average gain in weight of the 5 rats fed cod-liver oil was only 2 grams for the 8-day feeding period. It was concluded that ash analyses are of no value in determining the vitamin D value of a food when short feeding periods are used, a conclusion reached by Tabor, Dutcher, and Guerant⁽²⁴⁾ when even longer feeding periods were used, and confirming the earlier work of Adams and McCollum.⁽¹⁾

To determine whether or not the calcium and phosphorus contents of the opihi supplements influenced the healing of rickets, as judged by the line test, 4 rachitic rats were fed a mixture of calcium and phosphorus salts (CaCO_3 and Na_2HPO_4) equivalent to the quantity of calcium and phosphorus found in 2 grams of opihi. In addition, opihi were ashed at dull red heat in an electric muffle and a quantity of the resulting ash equivalent to 2 grams of opihi was fed daily for 8 days to each

TABLE 6.—Average quantities of ash and calcium in the femurs of rats used for the line test.

Kind and quantity of daily supplement.	Number of rats.	Ash in fresh femurs.	Calcium in fresh femurs.	Calcium in ash of femurs.	Average gain in weight for 8 days.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
Basal diet only (21 days).....	6	14.0	5.0	35.8	-----
Basal diet only (29 days).....	5	12.5	4.4	35.0	5
Cod-liver oil.....	5	15.3	5.5	35.6	2
Opihi, whole, 3 grams.....	10	11.9	4.2	35.2	17
Opihi, whole, 4 grams.....	5	13.4	4.7	35.0	14
Viscera without gonads 1 gram.....	7	13.5	^a 4.6	^a 35.2	11
Ovaries 1 gram.....	8	15.5	5.5	35.2	17
Testes 1 gram.....	6	17.3	6.3	36.1	16

^a Average for 5 rats.

of 9 rachitic rats. Subjected to the line test, the tibias of these 13 rats showed no evidence of healing rickets and appeared quite like those of the negative controls.

The experiments here reported were completed two years before the publication of Coward's book,(9) but her method for evaluating the units of vitamin in an unknown by plotting the logarithms of the doses has been used.(9, pp. 116, 117) The number of rats fed the international standard for series B was not equal to the number fed the supplements, as Coward recommends. We used both 21- and 29-day negative controls from each litter. The remainder of the rats in each litter were divided, so that some received supplements of the standard and others the substance to be tested.

With the use of the method of Coward, referred to above, and the results of the daily feeding of 2 grams of opihi, the units of vitamin D per gram would be 0.35; on the basis of the 3 grams dose the value would be 0.29 unit of vitamin D per gram. It may be noted from Table 7 that the results of feeding 3 grams of opihi are similar in the two series.

The above vitamin D values for whole opihi were obtained by comparing the results for opihi-fed animals with the results for 22 rats fed 0.5 unit of the international standard or reference cod-liver oil daily for 8 days, and 10 rats fed 1 unit daily for 8 days. The average results for the standards were 2.1+ healing for those fed 0.5 unit and 3.7+ healing for those fed 1 unit. If more rats had been fed 1 unit daily the average healing would probably have been less than 3.7+. Bills et al.(5) have produced a curve based on the protocols of 4,000 rats to

TABLE 7.—*Summary of observed healing in rachitic rats of series A and B.**

Supplements.		Series A.		Series B.	
Kind.	Quantity.	Number of rats.	Rating.	Number of rats.	Rating.
International Standard and reference cod-liver oil.....	0.5 unit.....			22	2.1+
	1 unit.....			10	3.7+
Ophi.....	1 gram.....			11	2.4+
	2 grams.....	3	2.3+	18	2.9+
	3 grams.....	10	3.2+	12	3.4+
	4 grams.....	12	3.8+		
	5 grams.....	4	4.0+		
Viscera, total soft parts.....	1 gram.....			11	3.9+
Viscera, without gonads.....	1 gram.....	28	3.2+		
Ovaries.....	1 gram.....	12	3.9+		
Testes.....	1 gram.....	10	3.9+		

* Data obtained by adding the total number of plus signs for all the rats in each group and dividing by the number of rats in the group.

show the degree of healing when the dose of an antirachitic substance is increased by different multiples. According to their curve the expected healing for 1 unit of the international standard, based on our results for 0.5 unit, should be 3.2+ instead of 3.7+. Had more rats been fed 1 unit, doubtless a figure nearer to 3.2+ would have been obtained. If the theoretical figure of 3.2+ instead of 3.7+ is used as the healing value for 1 unit and the logarithms of the doses are plotted as recommended by Coward, the units of vitamin D per gram of whole opihi (based on the data for the rats fed 2 and 3 grams daily) would be 0.41 and 0.38 units instead of 0.35 and 0.29 units—increases of 17 and 31 per cent, respectively. However, as Bills et al.(5) have shown by statistical treatment of large quantities of data that the line test for vitamin D as carried out in their laboratory has a probable error of about 10 per cent when 20 rats are used for an assay, we can conservatively use the figure of 0.30 unit of vitamin D per gram or 30 units per 100 grams of whole opihi as an average figure.

This value is six times greater than that for other shellfish that have been investigated. Daniel and Munsell (1937) have assigned to oysters and clams values of 5 international units of vitamin D per 100 grams, although the original data on which their estimates are based have been obtained from experiments with but a small number of animals.(15,26) Our analysis of opihi showed 1.7 per cent ether extract, which appeared as a dark-colored oil. If all the vitamin D were contained in the

oil it would have approximately 1,760 units per 100 grams, a value which is low compared with that of average cod-liver oil (10,000 units per 100 grams) and other fish oils.

Though no tests were made involving the use of the foot and mantle only, it is probable that they contain proportionately as little vitamin D as vitamin A, and that all or nearly all the vitamin D may be found in the viscera. Tests on viscera with and without gonads, and separate tests with ovaries and testes, indicate that they all contain about 4 times as much vitamin D per gram as whole opihi, and that the gonads contain somewhat more vitamin D than other parts of the viscera (intestinal tract and hepatopancreas).

Though babies in ancient Hawaii were sufficiently exposed to sunshine to insure an adequate supply of vitamin D, the feeding of the soft parts of opihi as one of their earliest foods assured them of an excellent source of vitamin A and a good source of additional vitamin D.

FOOD OF THE OPIHI

The problem of how marine animals acquire their vitamin A and vitamin D contents continued to be worthy of investigation. When the first series of experiments showed opihi to be a relatively good source of these two vitamins, it was thought that some answer to the question might be gained from a study of opihi in an aquarium where the feeding and other experimental conditions could be controlled. However, all efforts to raise or maintain opihi in the large salt-water aquarium of the University of Hawaii were unsuccessful, although all manner of tropical and semitropical fish have been kept there. It was thought, however, that a study of the food of the opihi might throw some light on the origin of their vitamin A and D contents. Marie C. Neal, Botanist at the Bernice P. Bishop Museum, Honolulu, was engaged to make an examination of the alimentary tract of 16 specimens of opihi chosen from a much larger collection of the shellfish from the islands of Molokai and Oahu. As soon as they were removed from the rocks to which they had been clinging, the opihi were placed in either alcohol or formalin to kill them instantly and check the digestion of food. Below is a brief summary of the report prepared by Miss Neal:⁵

⁵The details of the study are on file at the Bishop Museum and the University of Hawaii, Honolulu.

Whenever possible, samples for microscopic study were taken from three parts of the alimentary tract—stomach, intestine, and rectum. Scrapings from the outer surface of the opihi shells were also carefully examined. Perfect specimens of algæ from these scrapings were compared with the contents of the alimentary tract of the opihi, which contained minute fragments resulting from the rasping of the mollusk's radulæ over the growth of algæ on the rocks and from the disintegrating action of the digestive juices of the opihi on the ingested algæ.

As a result of careful microscopic examination of the shell scrapings and of the contents of the digestive tracts of the opihi, it is concluded that the animals graze on minute algæ and juvenile forms of small algæ growing on the rock surfaces where the opihi cling. The digestive tracts of the opihi examined contained the following algæ:⁶ Myxophyceæ (blue-green algæ): *Hydrocoleum* sp., *Lyngbya* sp., *Microcoleus* sp., and undetermined genera and species; Chlorophyceæ (green algæ): *Cladophora* sp. and *Enteromorpha* sp.; Phæophyceæ (brown algæ): *Ralfsia* sp., and *Ectocarpus* sp.; Rhodophyceæ (red algæ): *Erythrotrichia* sp.; Bacillariaceæ (diatoms): many undetermined genera and species.

Many of the algæ found in the digestive tracts are similar to those growing on the outer surface of the shells of the opihi. The most abundant algæ in the habitat of the opihi seemed to be forms of minute blue-greens, which grow as small tufts of filaments or soft gelatinous layers of colonies, some including much lime. Apparently the lime was not consumed, whereas the algæ were. The two green algæ and *Ectocarpus* sp. were eaten in extremely juvenile states, presumably shortly after germination. The two green algæ, the red alga, and *Ectocarpus* sp., all filamentous forms, were easily digested. The brown alga, *Ralfsia* sp., which forms flat crusts of closely associated filaments on rocks, was well digested.

In another investigation of algæ on the reefs of Oahu, diatoms have been found, alone and in colonies, almost invariably present in fine material scraped from rocks, mixed with sand, silt, and small algæ. Owing to their small size, diatoms can easily be taken into the mouths of opihi, both in colonies and with larger plants, and can then pass through the alimentary tracts. Their

⁶ Thanks are due Mr. C. C. Jao, National Research Institute of Biology, Academia Sinica, Nanking, China, for assistance in determining the genera of the algæ.

siliceous shells are apparently impervious to digestive juices, but the IKI test for detection of protein, applied to opihi feces containing diatoms, showed that the protoplasmic contents of the diatoms were lacking. Possibly the protoplasm was extracted by enzyme action. The gelatinous matter joining diatoms in colonies may also be food for the opihi. The small amount of diatoms, compared with the large amount of other algal forms present in the alimentary tract, as well as the minuteness of diatoms, indicate that the latter are a minor source of the food of opihi.

Whether or not the opihi obtain their vitamin D from their food or whether they synthesize it could perhaps be determined by a protracted and thorough study of the algæ and diatoms on which they feed. The opihi crawl about the racks and are often exposed to bright sunlight; the edge of the mantle extends beyond the shell, and certainly must come in contact with the sun's rays. Reflected rays from the rocks must also reach the foot. Much of the food of the opihi, although washed by the waves, is at least intermittently exposed to sunshine. Despite the low fat content of opihi, revealed by chemical analysis, one might anticipate a greater vitamin D content than the assay shows to be present. On the other hand, the vitamin A activity of the opihi, due either to some precursors or to vitamin A itself or to both, must come originally from the algæ consumed by the opihi.

Copping,⁽⁸⁾ who has studied the vitamin D content of dried copepod material, has also reviewed the work of others who have studied the vitamin A and D contents of zoö- and phytoplankton. The results of all previous work seem to establish the fact that zoö- and phytoplankton are better sources of vitamin A than of vitamin D.

The relatively lower vitamin D than vitamin A content of opihi would suggest the inability of the opihi to synthesize vitamin D, or might reflect merely the proportionate quantities of these two vitamins which may occur in their food.

REPRODUCTION

An effort was made to determine whether or not the breeding season of the opihi was confined to certain periods of the year, as it was believed that the quantity of gonad tissue present would probably affect the vitamin A and D content of the

whole opihi. During a period of 12 months, 161 shellfish were carefully weighed to determine the percentage weight of gonads in relation to the weight of the whole edible opihi. The relative weight of gonads was greatest during October, November, and December (about 15 per cent), and smallest during May, June, and July (about 7 per cent) for the year studied, the average gonad weight for the year being 11 per cent of the total body weight. Many more samples would have to be weighed each month over a period of years to determine if this variation in weight of gonads occurs regularly. Microscopic examination of a large number of testes and ovaries showed mature reproductive cells (ova or spermatids) to occur in variable numbers, but they were always present during all seasons of the year.

SUMMARY

1. The opihi, or Hawaiian limpet (*Helcioniscus exaratus* Nuttall and *H. argentatus* Sowerby), has been analyzed for moisture, protein, ether extract, total ash, calcium, phosphorus, iron, copper, silicon, and glycogen. Separate analyses have been made of the solid portion (foot and mantle) and of the viscera. Moisture, protein, ether extract, and total ash have been determined for the ovaries and for the testes. Opihi are a good dietary source of protein, calcium, and iron.

2. Experiments with anæmic rats showed that the feeding of opihi, which are low in copper, did not result in any marked regeneration of hæmoglobin until this mineral was added.

3. Whole fresh opihi contain, per 100 grams, approximate quantities of the vitamins as follows: 4,000 international units of vitamin A, 130 Sherman-Bourquin units of vitamin B₂ (G) (300 γ flavin), and 30 international units of vitamin D. They contain little or no vitamin B₁ and are devoid of vitamin C.

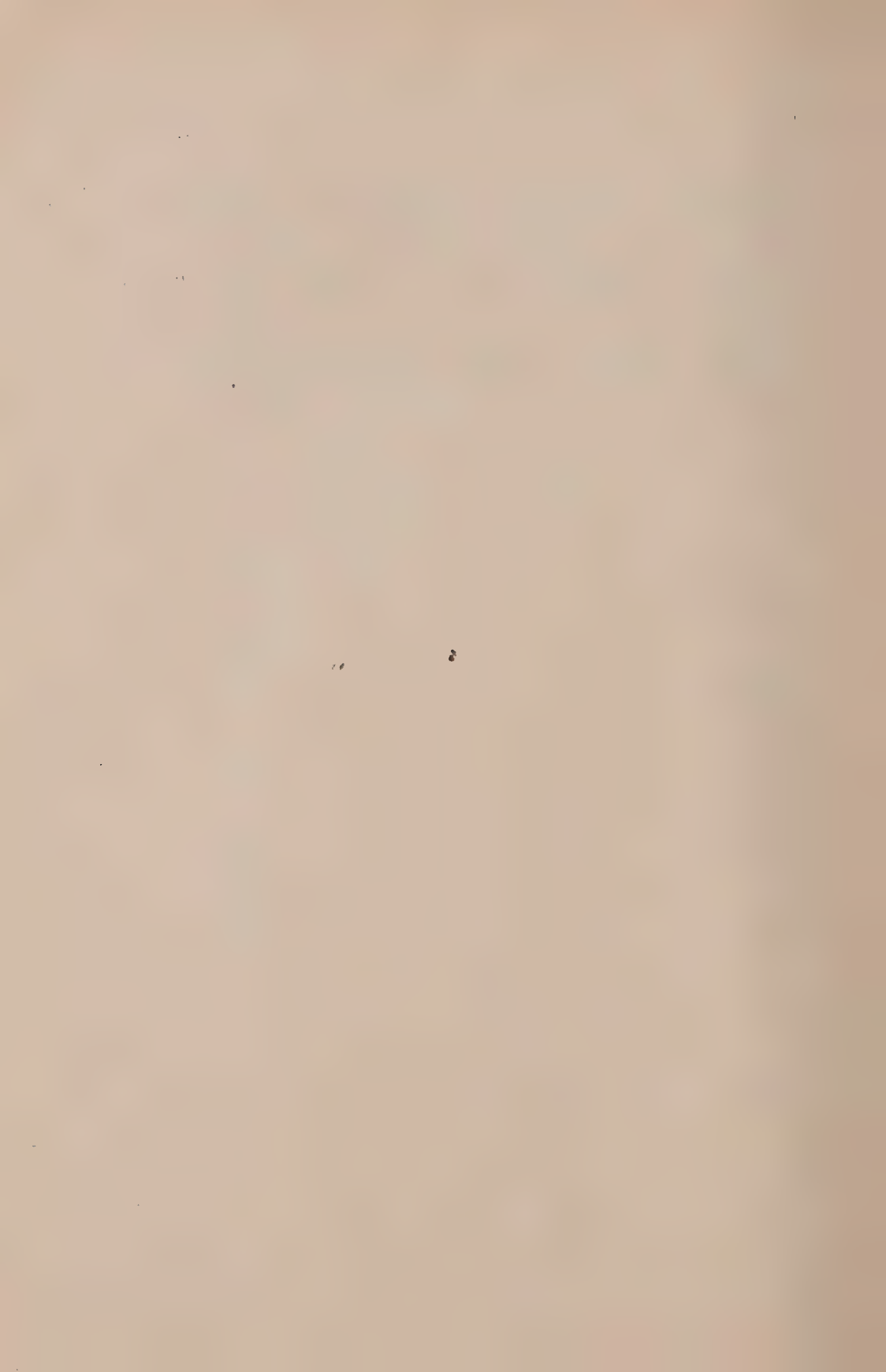
4. A study of the contents of the digestive tracts of the opihi showed that their food consists largely of blue-green and other algæ, and that diatoms, although present, are probably a relatively unimportant food source.

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ILLUSTRATIONS

PLATE 1. HELEIONISCUS SP.

FIG. 1. Dorsal aspect of shell; 2, ventral aspect; 3, dorsal aspect after removal from shell; 4, digestive organs lifted to show testis—large light-colored mass; 5, digestive organs lifted to show dark-colored ovary below.

TEXT FIGURE

FIG. 1. Average gain in weight of groups of young rats fed opihi and the international standard carotene. The quantities indicated were feed weekly. The numbers in parentheses show the number of rats used for each test.



1



2



3



4



5

A NEW GOBIOID FISH FROM LUZON

By HILARIO A. ROXAS and GUILLERMO J. BLANCO

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ONE PLATE

APARRIUS SABAGENSIS sp. nov.

Dorsals VI, I-10; anal I, 9; pectorals, 20; caudal, 22; 46 to 49 scales in longitudinal series, 13 scales in transverse series, 16 scales before first dorsal.

Head low, narrower than body, 5.5 times in total length and equal to caudal; snout slightly convex, 4 times in head; eyes high, dorsolateral, equal to snout; pupil white, equal to snout; interorbital space narrow, 0.67 diameter of eye; mouth small, oblique, upper and lower jaws equal in length; posterior angle of maxillary under anterior third of eye or below anterior part of pupil; teeth microscopic, two rows above and three rows below, with a pair of small outward canines in outer jaw; tongue short, slightly notched, adnate to tip; head and opercles naked.

Body elongate, laterally compressed; depth 5 times in total length; dorsal outline slightly arched; trunk with ctenoid scales, breast, nape, and pectoral base with small cycloid scales; pores absent on anterior and posterior part of interorbital space. Depth of caudal peduncle twice in head; caudal pointed.

Dorsals well separated, their height a little more than 0.66 depth of body. Second dorsal spine slightly elongated, thread-like; posterior ray of second dorsal short, not reaching caudal; pectorals and pelvic pointed, equal in length.

Alcoholic specimens pale yellow to white, with transverse irregular dark specks on scales on lateral sides of body; or a pigmented blackish spot below eye; a blackish spot on pectoral base; first dorsal spines alternately black-spotted; membranes of first dorsal with three to five rows of dark bands; second dorsals with three or four rows of dark spots; anal colorless; live specimens transparent yellowish.

Here described from 30 specimens, one type specimen, Cat. No. 41994, and cotypes, 29 to 58 mm long, collected from Cagayan River, barrio Catayaon, Lallo, Cagayan Province, January 31, 1939, and deposited in the ichthyological collection of

the Division of Fisheries of the Department of Agriculture and Commerce.

Table 1 shows a comparative study of the external characters of the species of the genus *Aparrius*.

TABLE 1.—External characters of species of *Aparrius*.

Species.	Distribution.	Scales in longitudinal series.	Scales in transverse series.	Body pigmentation.	Caudal.
<i>A. acutipinis</i>	Abra River, Cagayan.....	26-29	7-8	No black longitudinal bands on side.	Sharply pointed, longer than head.
<i>A. moloanus</i>	Molo, Panay Island.....	38-42	13-14	Two black longitudinal bands on side.	Not acutely pointed, as long as head.
<i>A. aurocingulus</i>	Ovalau Islands, Fiji Islands.....	56	18-20	With spots and blotches of light brown and golden.	Similar to <i>A. acutipinis</i> .
<i>A. sabagensis</i>	Catayaocan, Lal-lo, Cagayan, Luzon.	46-49	13	Transverse irregular bands.	Similar to <i>A. moloanus</i> .

Aparrius sabagensis is close to *A. moloanus* in the number of dorsal and anal spines and shape of caudal, but differs from the latter in the greater number of scales in the longitudinal series, and in the smaller number of scales in the transverse series. It also differs remarkably in pigmentation. The adult goby is named *sabay* in Ibanag. It is undoubtedly another source of *ipon* (goby fry) of the Cagayan River.

Measurements.—Total length, 71 mm; standard length, 58; length of head, 13; width of head, 7; width of mouth, 4; width of gill opening, 8; depth of body at anal origin, 14; width of body, 6; length of pectoral, 8; width of pectoral base, 5; length of ventral, 8; width of ventral, 4; length of caudal, 13; snout to origin of first dorsal, 19; snout to origin of anal, 30; lower jaw to chin, 5.

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ILLUSTRATION

[Drawn by Nemesio Dimanlig, Jr.]

PLATE 1. *Aparrius sabagensis* sp. nov.

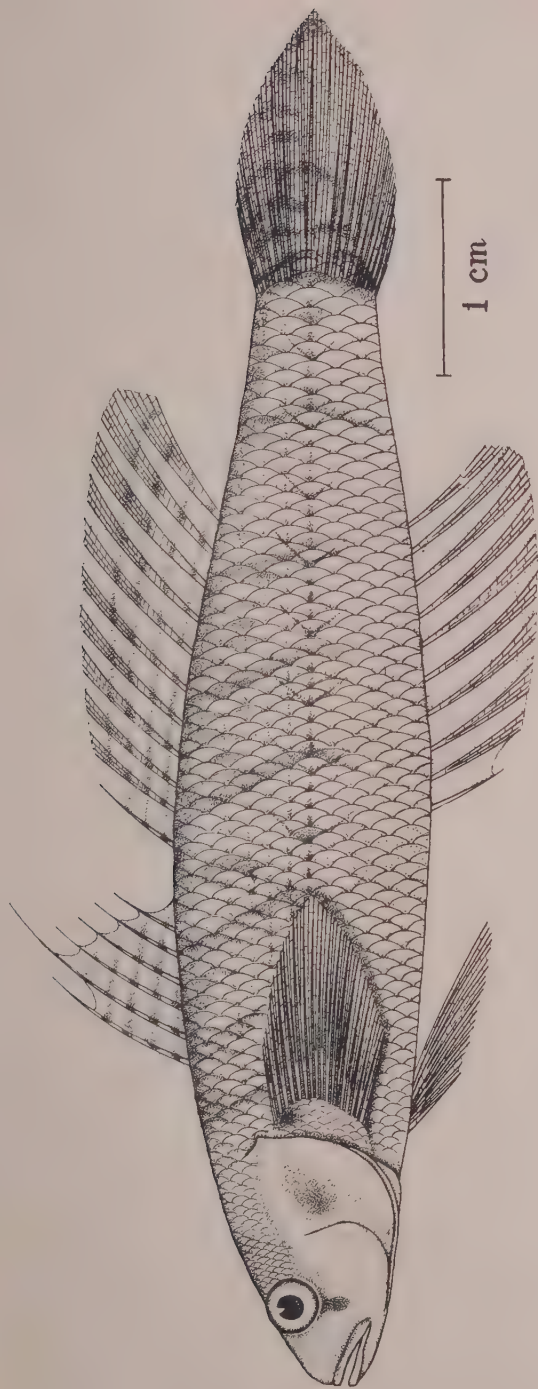


PLATE 1. *APARRIUS SABAGENSIS* SP. NOV.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XLII¹

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

FOUR PLATES

The exceptionally interesting crane flies described at this time were taken at various stations on Mount Omei, Szechwan, western China, by Mr. Tsen Bao-chi. Mr. Tsen undertook the present trip during late May and early June, 1938, acting under the direction and guidance of the Reverend Mr. George Meredith Franck. In late May, great masses of snow still persisted at the higher altitudes on the mountain, and the relatively few species of Tipuloidea taken were virtually all winter and early spring forms, including no fewer than 8 species of Trichoceridæ. By mid-June at the summit, and progressively earlier at the various temples lower down the mountain (White Cloud, 9,000 feet; Chu Lao Tong, 6,500 feet; Flying Bridges, 3,000 feet), numerous Tipulidæ of the spring fauna were on the wing. I am greatly indebted to Mr. Franck and to Mr. Tsen for their further efforts to make known the rich tipulid fauna of Mount Omei. It may be noted that already some 325 species of crane flies have been secured at various altitudes on Mount Omei. In the present paper the recording of the genus *Lipsothrix* Loew adds another element to the unusually long list of genera and subgenera in the Chinese fauna.

TIPULINÆ

TIPULA (NIPPOTIPULA) BREVIFUSA sp. nov. Plate 1, fig. 1.

Mesonotum dark brown, lateral portions light yellow; nasus lacking; antennæ with pedicel clear orange, flagellum black; femora obscure yellow, with a narrow, dark-brown, subterminal ring; tibiæ and tarsi black; wings with ground color strongly infumed, conspicuously patterned with dark brown and whitish subhyaline; m-cu at or just before midlength of M_{3+4} , the ap-

¹ Contribution from the entomological laboratory, Massachusetts State College.

parent mediocubital fusion thus relatively short; abdomen reddish yellow, outer segments uniformly brownish black.

Male.—Length, about 35 to 36 millimeters; wing, 23 to 24; antenna, about 6 to 6.5.

Frontal prolongation of head yellowish gray above, blackened on sides, nasus lacking; palpi black. Antennæ with scape brown, pedicel clear orange, flagellum black; flagellar segments short, basal enlargement only moderately developed; verticils much longer than segments. Front and anterior orbits light yellow, posterior orbits more brownish yellow; center of vertex and occiput with a dark-brown median line.

Pronotum dark brown medially, yellow on sides. Lateral border of præscutum and dorsopleural membrane light yellow, contrasting with the dark-brown remainder of notum; median line of scutum narrowly pale. Pleura variegated dark brown and pale, dorsal pleurites darker than ventral pleurites, narrowly lined longitudinally with pale, including a more silvery area on ventral pleurotergite; meral region pale. Halteres with stem reddish brown, base of small knob dark brown, apex reddened. Legs relatively short and stout; coxæ pale brown, tips paler, posterior pair more uniformly darkened; trochanters testaceous brown; femora obscure yellow, with a narrow dark-brown ring before subequal pale apex; tibiæ and tarsi black, tibial bases restrictedly pale. Wings (Plate 1, fig. 1) with ground color strongly infumed, clear yellowish in costal region; a conspicuous dark-brown and whitish subhyaline pattern, as follows: Dark area at arculus, continued outwardly to wing margin as a broad seam along vein Cu, somewhat more expanded into cell M at near midlength of vein; a small cloud at origin of Rs; stigma darker, involving also the anterior cord, enclosing a small pale area just above fork of Rs; small marginal darkenings at ends of veins R_{4+5} to 2d A, these diffuse and more or less confluent at margin though variegated by small cream-colored droplets at ends of cells; whitish subhyaline areas chiefly in radial field, before and beyond origin of Rs, and post-stigmal in outer radial cells; a narrow oblitative streak along posterior edge of cell 1st M_2 ; veins brownish yellow, darker in clouded portions. Venation: Rs more than twice as long as m-cu, the latter at or just before midlength of M_{3+4} .

Abdomen relatively long, reddish yellow, tergites more darkened sublaterally, becoming more extensively so on outer segments, hypopygium and preceding segments uniformly dark-

ened; lateral borders of tergites narrowly buffy. Hypopygium large, massive.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*). Paratopotype, male.

Tipula (*Nippotipula*) *brevifusa* is quite distinct from its two closest allies, *T. (N.) anastomosa* Edwards, of the Federated Malay States, and *T. (N.) pulcherrima* Brunetti, of the Himalayan Region. It differs especially in the coloration of the wings and in the venation, notably the distal position of m-cu which gives the impression of a short mediocubital fusion.

TIPULA (VESTIPLEX) ERECTILOBA sp. nov. Plate 1, fig. 2; Plate 2, figs. 25 and 26.

General coloration of head and thorax gray; antennæ (male) very short, 12-segmented; mesonotal præscutum with three darker gray stripes; halteres elongate, obscure yellow, knobs weakly darkened; legs brownish black to black; wings fulvous brown, variegated with darker brown and yellowish-white areas, the latter including major markings across base of cell 1st M_2 and at near two-thirds length of cell M ; inner end of cell 1st M_2 pointed; basal abdominal segments reddish brown, tergites narrowly bordered laterally with black, outer segments uniformly darkened; male hypopygium with tergite a partly blackened saucer, cephalic portion elevated into an erect median lobe; caudal border of tergite with a linear median split; inner dististyle unusually broad and simple, its beak reduced to a small triangular point.

Male.—Length, about 14 to 17 millimeters; wing, 18.5 to 22.5; antenna, about 2.3 to 2.6.

Frontal prolongation of head relatively long, black, sparsely pruinose; nasus lacking or very short and stout; palpi black. Antennæ unusually short, only a little longer than head; scape and pedicel black; basal segments of flagellum brown or weakly bicolored, obscure yellow, darker at base, outer segments passing into brownish black; in cases antennæ uniformly black; basal flagellar segment cylindrical, nearly twice as long as second; second and succeeding segments short-cylindrical, without an evident basal enlargement; verticils short, subequal in length to segments; antennæ apparently only 12-segmented, usual thirteenth segment fused with penultimate. Head brownish gray, anterior orbits broadly light gray.

Pronotum dark brown, sparsely pruinose. Mesonotal præscutum light gray, lateral margins conspicuously darkened, disc

with three darker gray stripes, lateral pair poorly differentiated against ground; median stripe very broad in front, tapering rapidly behind, posterior end more or less split, in cases posterior interspaces with narrow dark lines before suture; scutal lobes light gray, variegated with darker gray; posterior sclerites of notum gray. Pleura dark gray. Halteres unusually long, about one and one-third as long as antennæ, obscure yellow, knobs weakly darkened. Legs with coxæ and trochanters gray; femora and tibiæ uniformly black; tarsi black or brownish black; claws simple. Wings (Plate 1, fig. 2) with a fulvous brown ground, variegated with darker brown and yellowish-white areas, the former including clouds at origin of Rs, cord, and as seams along vein 2d A and outer portion of Cu; the most conspicuous subhyaline areas lie across the cord and at near two-thirds length of cell M, the latter preceded and followed by pale-brown clouds; a similar dusky wash in cell R between arculus and origin of Rs; cell C clouded; clear yellow areas before and beyond stigma; veins brown, more yellow in costal areas. Venation: R_{1+2} preserved; m and petiole of cell M_1 subequal; inner end of cell 1st M_2 pointed.

Basal segments of abdomen reddish brown, tergites narrowly bordered by black; sternites similar, posterior borders narrowly darkened; sixth and succeeding segments blackened, pruinose. Male hypopygium (Plate 2, fig. 25) relatively small and simple. Ninth tergite (Plate 2, fig. 26, 9t) with posterior half modified into a partly blackened saucer, as often occurs in the subgenus, but its structure quite distinct from that of other regional species; caudal margin of saucer heavily blackened, with a very narrow, parallel-sided median notch, lobes adjoining this median split microscopically roughened and with numerous small punctures; posterior portion of saucer yellow, only feebly chitinized except for a broad median strip which extends cephalad to form back wall of plate in restricted median portion only; viewed from the side (Plate 2, fig. 25, 9t) this narrow plate juts conspicuously above the level of the remainder of tergite as an erect lobe; posterior portion of tergite behind saucer divided medially by pale membrane, almost without punctures. Basistyle unarmed. Outer dististyle, *od*, a long-oval, flattened lobe, its apex obtuse. Inner dististyle, *id*, unusually broad and simple, the usual beak reduced to a small triangular point. Eighth sternite, 8s, unarmed.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, summit, altitude 11,000 feet May 26, 1938 (Tsen). Paratopotypes, 12 males.

Tipula (*Vestiplex*) *erectiloba* is very different from all other regional species of the subgenus, differing especially in the very short antennæ, elongate halteres, wing pattern, and especially the structure of the male hypopygium.

TIPULA (VESTIPLEX) FACTIOSA sp. nov. Plate 1, fig. 3; Plate 2, figs. 27 and 28.

Allied to *deserrata*; antennæ relatively short, flagellum black; mesonotal præscutum olive-gray, with four brown stripes that are more or less completely bordered by darker; posterior sclerites of notum with a capillary dark line; femora obscure yellow, tips narrowly blackened; tibiæ and tarsi black; claws (male) toothed; wings narrow, with long basal petiole, grayish brown, variegated with darker brown and subhyaline areas; cell 2d A relatively narrow; basal four abdominal segments yellow, trivittate with brownish black, outer segments blackened; male hypopygium with tergite completely divided medially, adjoining mesal-apical lobes narrow, their inner margins conspicuously serrulate; basistyle with an unusually powerful black spine; inner dististyle a broadly flattened disc, rostral portion long and slender.

Male.—Length, about 15 to 16 millimeters; wing, 17 to 20.5; antenna, about 2.8 to 3.

Frontal prolongation of head brownish yellow; nasus very long; palpi dark brown. Antennæ relatively short, only a little longer than palpi; scape and pedicel yellow, flagellum black; flagellar segments subcylindrical, not or only slightly incised, basal swelling small; verticils subequal in length to segments. Head brownish gray, anterior vertex and posterior orbits more buffy; central portion of posterior vertex with a brownish median stripe.

Pronotum olive-gray, variegated with darker. Mesonotal præscutum olive-gray, with four brown stripes, intermediate pair separated by a pale line that is narrowly bordered by darker brown, lateral stripes similarly bordered; scutum buffy yellow, variegated with brown; scutellum testaceous; mediotergite olive-gray; a nearly continuous capillary brown line extending from suture to abdomen. Pleura yellow, variegated with more grayish areas on ventral anepisternum and ventral sternopleurite. Halteres with stem obscure yellow, base of knob blackened, apex

pale. Legs with coxæ greenish yellow; trochanters yellow; femora obscure yellow, brighter at base, tips narrowly blackened; tibiæ and tarsi black; claws (male) with basal tooth. Wings (Plate 1, fig. 3) relatively narrow, prearcular field long and narrow; grayish brown, variegated with slightly darker brown and subhyaline areas; cell C uniformly yellow, Sc slightly more darkened except at outer end; stigma dark brown; paler brown clouds at origin of Rs, cord, outer end of cells R_2 and R_3 , beyond midlength of cell M, and postarcular in bases of cells R and M; the major subhyaline areas occur before and beyond the cord, postarcular in both cells R and M, before outer end of cell M, and in axillary region; smaller pale areas in outer ends of cells 1st A and 2d A; veins dark. In the female the dark pattern is somewhat heavier and more contrasted. Venation: R_{1+2} entire; m subequal to petiole of cell M_1 ; Rs from two to two and one-half times m-cu; cell 2d A relatively narrow.

Abdomen with basal four tergites yellow, with three conspicuous brown to brownish-black lines, sublateral stripes narrower than buffy margins; median stripe broader; fifth and succeeding segments more uniformly blackened, lateral borders of more basal segments pale; basal sternites pale, outer segments darkened. Genital shield of female black; cerci elongate, deep, with smooth margins. Male hypopygium with ninth tergite (Plate 2, fig. 27, 9t) completely divided on midline by pale membrane, mesal-apical angles produced into narrow blackened lobes, their inner margins conspicuously serrulate. Basistyle (Plate 2, fig. 28, b) with an unusually strong and powerful black spine, directed chiefly dorsad. Outer dististyle, *od*, a flattened clavate lobe provided with numerous setæ. Inner dististyle, *id*, with a long slender beak; posterior portion of style a flattened obtuse disc, with scattered setæ. Eighth sternite extensive, margin without armature.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*). Allotopotype, female. Paratopotypes, 3 males; paratype, male, Kwanhsien, altitude 2,000 feet, May, 1933 (*Graham*).

Most closely related to *Tipula* (*Vestiplex*) *deserrata* Alexander, agreeing in the strongly spined basistyle and in the ninth tergite being entirely divided medially by a pale membrane, with the adjacent lobes heavily blackened and serrulate. It differs especially in several features of the male hypopygium, especially

of the tergite, basistyle, and dististyles. I am placing these species in *Vestiplex* despite the nonserrated cerci. A further discussion of Indo-Chinese species of *Tipula* on the borderline between *Vestiplex* and *Oreomyza* has been published elsewhere.²

TIPULA (OREOMYZA) STERNOSETOSA sp. nov. Plate 1, fig. 4; Plate 2, figs. 29 and 30.

General coloration buffy gray, præscutum with four darker brownish-gray stripes; antennæ with scape and pedicel yellow, flagellum black; frontal prolongation of head above light yellow; apex of knob of haltere yellow; femora black, obscure yellow at base, with a conspicuous obscure yellow subterminal ring; tibiæ black; wings brown, variegated with yellow; R_{1+2} entire, m-cu shortly before fork of M_{3+4} ; abdominal tergites yellow, trivittate with black, median stripe broad and continuous, outer segments blackened; male hypopygium with outer dististyle unusually long and slender, black; basistyle on mesal face produced caudad into a strong blackened rod; eighth sternite with numerous, very long, erect, pale setæ.

Male.—Length, about 13 millimeters; wing, 15; antenna, about 4.

Female.—Length, about 17 to 18 millimeters; wing, 16 to 16.5.

Frontal prolongation of head light yellow above, slightly darker on sides; nasus distinct. Antennæ of moderate length; scape and pedicel light yellow, flagellum black; flagellar segments subcylindrical, very feebly incised, basal swellings correspondingly small; longest verticils a little shorter than segments; terminal segment small, thimble-shaped. Head buffy yellow, central portion of vertex weakly darkened.

Pronotum buffy, with a narrow brown median mark. Mesonotal præscutum buffy gray, with four darker brownish-gray stripes that are very indistinctly margined with darker; setigerous punctures pale and inconspicuous; posterior sclerites of notum gray, each scutal lobe with two darker areas; scutellum and mediotergite with a capillary darkened median line. Pleura gray. Halteres with stem yellow, knob dark brown basally, apex broadly yellow. Legs with coxæ gray; trochanters yellow; femora obscure yellow at base, more broadly so on forelegs, narrower on posterior femora; beyond base ground color black, with a narrow, obscure, yellow, subterminal ring before broader black tips; tibiæ and basitarsi black, terminal tarsal segments somewhat paler; claws (male) with an erect spine. Wings

² Philip. Journ. Sci. 57 (1935) 118, 119.

(Plate 1, fig. 4) brown, handsomely patterned with pale yellow; prearcular and costal fields deeper yellow; chief yellow areas as follows: a major area beyond postarcular darkening, in both cells R and M; before and beyond stigma; near outer end of cell M; across base of cell 1st M_2 ; basal portion of Cu and in anal cells; cell 2d A uniformly yellow with exception of a large marginal cloud at near midlength; veins pale brown, more yellowish in brightened areas. In the female the yellow areas are even more extensive. Venation: R_{1+2} entire; m-cu shortly before fork of M_{3+4} .

Abdominal tergites yellow, with a broad, continuous, blackened, median stripe and somewhat narrower sublateral stripes that are interrupted at posterior margins of segments; lateral borders of tergites gray; sternites yellow with a median dark line; outer abdominal segments passing into black. Male hypopygium (Plate 2, fig. 29) with ninth tergite, 9t, fused with sternite, 9s, on its cephalic portion; basistyle, b, with suture complete but pale and membranous on dorsal portion; apex of basistyle slightly produced. Ninth tergite (Plate 2, fig. 30, 9t) with caudal margin evenly concave, lateral lobes blackened but relatively small and low, ventrad of these lobes with further chitinized extensions; ventral surface of tergite with transverse arms that meet in middle to form an obtuse median lobe. Basistyle, b, on mesal face with a strong blackened rod. Outer dististyle, od, subequal in length to latter, unusually long and slender, dark-colored, provided with long setae that are chiefly unilateral in distribution except at tip. Inner dististyle, id, with rostral beak stout; posterior angle of style produced into a conspicuous rounded lobe. Eighth sternite, 8s, unarmed, ventral surface with numerous, very long, erect, pale setae (the punctures indicated in the figure).

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, June 17, 1938 (Tsen). Allotopotype, female. Paratopotype, female.

Tipula (*Oreomyza*) *sternosetosa* is generally similar to species such as *T. (O.) percommoda* Alexander, differing in many characters, as the yellow frontal prolongation of head, yellow femoral ring, and especially the structure of the male hypopygium, as the tergite outer dististyle, sclerotized rod of the basistyle, and the conspicuous vestiture of the eighth sternite.

TIPULA (OREOMYZA) INCISURATA sp. nov. Plate 1, fig. 5; Plate 2, figs. 31 and 32.

General coloration light gray, præscutum with four entire, more brownish stripes; antennæ relatively long, if bent backward extending to some distance beyond base of abdomen; scape and pedicel yellow, flagellum black, verticils shorter than segments; wings strongly infumed, variegated with yellow and cream-colored areas; R_{1+2} entire, R_s long; basal abdominal segments reddish yellow, narrowly trivittate with brownish black; outer abdominal segments, including hypopygium, black; male hypopygium with caudal margin of tergite with a small but deep median notch, on dorsal surface this continued cephalad as a deep median furrow for almost length of sclerite; lateral tergal lobes broad, obliquely truncated, outer lateral angles obtuse.

Male.—Length, about 14 millimeters; wing, 15; antenna, about 6.

Frontal prolongation of head black, sparsely pruinose; nasus reduced to a small lobe; palpi black. Antennæ (male) relatively long, if bent backward extending to some distance beyond base of abdomen; scape and pedicel yellow, flagellum black, first segment restrictedly brightened at base; flagellar segments moderately incised, verticils unilaterally distributed, shorter than segments, all arising from the small basal enlargement. Head yellowish gray, orbits narrowly lined with clearer gray; posterior orbits narrowly bordered internally by lines of darker brownish gray; vertical tubercle very low.

Pronotum gray, variegated with darker. Mesonotum light gray, with four entire, more brownish stripes, median interspace obscured; scutal lobes darkened; posterior sclerites of notum light gray, each with a central darker area. Pleura gray, variegated with darker gray, especially on ventral sternopleurite and meron; dorsopleural membrane dark buffy. Halteres relatively long, stem obscure yellow, knob darkened. Legs with coxæ gray; trochanters yellow; remainder of legs black, femoral bases restrictedly light yellow; femora with faintest possible indication of a more brightened subterminal ring; claws (male) with erect basal tooth. Wings (Plate 1, fig. 5) with ground color strongly infumed, variegated with more yellowish and creamy-white areas; cell Sc and most of prearcular field yellow; stigma brown, slightly darker than ground; the chief yellow areas are in bases of cells R and M , at near two-thirds length of M , immediately before origin of R_s , in outer end of

cell R, and poststigmal; smaller pale areas in cells Cu and 1st A; a more creamy-white area crosses cell 1st M_2 into base of cell M_3 ; veins dark, paler in brightened areas, especially obliterative ones at cord. Venation: R_{1+2} entire, straight; Rs long, about two and one-half times m-cu; petiole of cell M_1 a little less than m.

Basal abdominal tergite pruinose basally; succeeding segments reddish yellow, narrowly trivittate with brownish black; fifth and succeeding segments, including hypopygium, passing into black. Male hypopygium (Plate 2, fig. 31) with the basistyle, *b*, entire, not produced, provided with long yellow setæ. Ninth tergite (Plate 2, fig. 32, 9t) with a small but deep rectangular median incision, from base of which a long furrow on dorsal surface continues cephalad for almost the entire length of the sclerite; lateral tergal lobes broad, obliquely truncated, outer lateral angles obtuse; surface of tergite with numerous black setæ, marginal setæ small and slender. Outer dististyle narrow, pale, with conspicuous setæ. Inner dististyle, *id*, with beak and a lobe beneath it heavily blackened. From base of ninth sternite on midline a small erect lobe juts ventrad. Eighth sternite narrow, simple.

Habitat.—China¹ (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, June 6, 1938 (*Tsen*). Paratopotype, male.

Tipula (*Oreomyza*) *incisurata* is quite different from all other regional species, especially in the structure of the male hypopygium, but likewise in the antennæ and in the pattern of the wings. Superficially it somewhat resembles other species of the genus belonging to various subgenera, as *T. (Vestiplex) inquinata* Alexander, *T. (Acutipula) omeiensis* Alexander, and *T. (Oreomyza) sex-lobata* Alexander.

TIPULA (OREOMYZA) INTERRITA Alexander.

Female.—Length, about 30 millimeters; wing, 9.5 by 1.3.

Characters as in male, differing most evidently in semi-atrophied wings. Nasus reduced. Antennæ 13-segmented, terminal segment small and closely applied to the penultimate. All tibiæ dirty brownish yellow, contrasting conspicuously with brownish-black femora. Wings reduced, as shown by measurements, venation correspondingly distorted; general coloration obscure yellow, stigmal region slightly more darkened; veins pale. Ovipositor with cerci very long and slender, straight,

with smooth margins; hypovalvæ much shorter and deeper, tips obtusely rounded.

Allotype, female, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, May 26, 1938 (*Tsen*).

Two further males are from the summit of Omei, altitude 11,000 feet, May 26, 1938 (*Tsen*).

CYLINDROTOMINÆ

LIOGMA SIMPLICICORNIS sp. nov. Plate 1, fig. 6; Plate 3, figs. 33 and 34.

General coloration polished black, dorsopleural membrane conspicuously yellow; antennæ black throughout, flagellar segments only moderately produced; halteres long, knobs infuscated; femora obscure yellow, passing through brown to brownish black; wings strongly suffused with brown, small stigma darker brown; r-m present; male hypopygium with dististyle narrowed on apical third, apex cultriform; gonapophyses appearing as narrowly expanded blades, surface at apex microscopically roughened.

Male.—Length, about 12 millimeters; wing, 9.5; antenna, about 3.4.

Rostrum and palpi black. Antennæ (Plate 3, fig. 33) black throughout; flagellar segments only moderately produced. Head polished black; anterior vertex a little wider than diameter of scape.

Pronotum black, posterior portion and dorsopleural membrane yellow. Mesonotal præscutum and scutum shiny black, surface smooth; scutellum pale, parascutella blackened; mediotergite black, sparsely pruinose. Pleura black, sparsely pruinose. Halteres relatively long and slender; stem dusky, yellow at base, knob infuscated. Legs with coxæ black; trochanters yellow; femora obscure yellow basally, passing into brown, tips brownish black; tibiæ brown, tips narrowly blackened; tarsi black. Wings (Plate 1, fig. 6) with a rather strong brown suffusion; stigma small, oval, darker brown; veins brown. Venation: Sc long, extending to beyond level of r-m, tip pale to atrophied; r-m present; m-cu shortly beyond fork of M.

Abdomen elongate, black, pleural membrane and incisures restrictedly paler; hypopygium black. Male hypopygium (Plate 3, fig. 34) with dististyle, *d*, narrowed on apical third, apex cultriform. Gonapophyses, *g*, appearing as narrowly expanded blades, surface at apex microscopically roughened; inner edge of stem with several strong setæ.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, May 25, 1938 (Tsen).

Liogma simplicicornis is quite distinct from the other eastern Asiatic species of the genus in the reduced pectinations of the antennæ, which here approach the normal unmodified condition found in the related *Phalacrocera*. Whether it will be possible to maintain as full genera such groups as *Liogma*, *Triogma*, and *Phalacrocera* seems questionable to me.

LIMONIINÆ

LIMONIINI

LIMONIA (DICRANOMYIA) AMPLIFICATA sp. nov. Plate 1, fig. 7; Plate 3, fig. 35.

Large (wing, male, over 8 millimeters); general coloration of thorax medium brown; halteres pale yellow throughout; femora obscure yellow, tips darker; wings broad, whitish subhyaline, stigma and seams at cord and outer end of cell 1st M_2 weakly darkened; Sc_2 not far from tip of Sc_1 ; male hypopygium with a single long rostral spine on ventral dististyle, this arising from a low hemispherical blackened tubercle placed before mid-length of prolongation.

Male.—Length, about 7.5 millimeters; wing, 8.5.

Rostrum brown, moderately long, about one-half remainder of head; palpi black. Antennæ brownish black; flagellar segments oval, incisures well-defined; terminal segment about one and one-half as long as penultimate. Head dark brown; anterior vertex narrow.

Pronotum dark brown. Mesonotum almost uniform medium brown, without markings; præscutal setæ black, conspicuous. Pleura medium brown, dorsopleural region darker. Halteres pale yellow throughout. Legs relatively short and stout; coxæ pale brown; trochanters pale yellow; femora obscure yellow, tips darker; remainder of legs brownish testaceous, outer tarsal segments darker; claws long, with a conspicuous basal spine; terminal tarsal segment with modified flattened setæ at base. Wings (Plate 1, fig. 7) broad, whitish subhyaline, stigma slightly darker; cord and outer end of cell 1st M_2 a trifle seamed with darker; veins brown, more yellowish in prearcular and costal fields. Venation: Sc_1 ending opposite origin of Rs , Sc_2 near its tip; free tip of Sc_2 lying shortly proximad of R_2 ; cell 1st M_2 large, about equal in length to vein M_{1+2} beyond it; m-cu at fork of M .

Abdomen brown, vaguely patterned with paler, especially on basal sternites; hypopygium dark, ventral dististyle whitened. Male hypopygium (Plate 3, fig. 35) with caudal margin of ninth tergite, *9t*, emarginate, lobes broadly rounded. Basistyle, *b*, with ventromesal lobe extensive, provided with numerous long yellow setæ. Dorsal dististyle a powerful, angularly bent rod, its apex a long blackened spine. Ventral dististyle, *vd*, smaller in extent than basistyle, rostral prolongation well set off by a slightly constricted neck; prolongation heavily blackened, especially at pointed apex and along lower or cephalic margin; a single rostral spine, arising from a low hemispherical black tubercle placed before midlength of prolongation; spine black, elongate, subequal in length to rostrum. Gonapophysis, *g*, with mesal-apical lobe a slender, curved, blackened spine.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, June 6, 1938 (*Tsen*).

Limonia (Dicranomyia) amplificata is very distinct from the other species of the subgenus so far described. From the other forms having a single rostral spine on the ventral dististyle of the male hypopygium it is readily told by the large size and details of structure of the male hypopygium. The most similar described species is *L. (D.) montium* Alexander, of the high mountains of Formosa.

LIMONIA (GERANOMYIA) OBESISTYLA sp. nov. Plate 1, fig. 8; Plate 3, fig. 36.

General coloration plumbeous brown, præscutum with three poorly indicated darker-brown stripes; rostrum relatively short, less than twice length of antennæ; legs yellow; wings yellow, with a rather restricted, chiefly costal, brown pattern; dark area at fork of *Sc* prolonged backward and outward to include fork of *Rs*; *m-cu* some distance before fork of *M*; male hypopygium with ventral dististyle unusually large, fleshy, rostral prolongation small, pointed at apex, with two straight spines from a low common tubercle; gonapophysis with mesal-apical lobe broad, tip acute.

Male.—Length, excluding rostrum, about 7 millimeters; wing, 7.5; rostrum, about 2.3 to 2.4.

Rostrum relatively short, black throughout, less than twice as long as antennæ. Antennæ with scape and pedicel dark brown, flagellum varying from pale yellowish brown to brown, outer segments darker; flagellar segments oval; terminal seg-

ment longer than penultimate. Head black, striplike anterior vertex silvery gray, this color continued caudad onto posterior vertex.

Mesonotal præscutum plumbeous brown, with three very poorly indicated darker-brown stripes; lateral border of sclerite paling to obscure yellow; scutal lobes plumbeous brown, their mesal edges with a darker-brown line that is a posterior continuation of lateral præscutum stripes; scutellum testaceous brown; postnotum dark. Pleura almost uniformly brownish testaceous. Halteres with stem yellow, knob infuscated. Legs with coxæ testaceous yellow; trochanters yellow; remainder of legs yellow, with only terminal tarsal segments darkened. Wings (Plate 1, fig. 8) with ground color yellow, slightly brighter in prearcular and costal fields; a conspicuous brown costal pattern, as follows: first area at h, continued caudad over arcus; second area at supernumerary crossvein in cell Sc, extending from C almost to M, nearly parallel-sided; third area at origin of Rs, slightly narrower and a little longer than second; fourth area at fork of Sc, continued caudad and slightly distad to involve fork of Rs; fifth area at stigma; sixth at tip of R_3 , crossing cell to vein R_{4+5} ; dark costal areas conspicuously narrower than interspaces; additional dark seams on cord, m-cu, outer end of cell 1st M_2 and at tip of vein R_{4+5} ; barely indicated marginal clouds at ends of veins M_4 to 2d A, inclusive; a very faint darkening in cell Sc between first and second major costal areas; veins yellow, darker in patterned areas. Costal fringe relatively short. Venation: Sc unusually long, Sc_1 ending a short distance before fork of Rs, Sc_2 at its tip; free tip of Sc_2 and R_2 in virtual transverse alignment; cell 1st M_2 about as long as vein M_{1+2} beyond it; m-cu approximately its own length before fork of M; vein 2d A strongly sinuous, cell wide.

Abdominal tergites dark brown, caudal borders of segments narrowly pale; sternites more extensively yellow, slightly darkened before tips; subterminal segments, including hypopygium, uniformly infuscated; ventral dististyle very large, conspicuously yellow. Male hypopygium (Plate 3, fig. 36) with lateral lobes of tergite, 9*t*, low. Basistyle, *b*, small, its area scarcely one-fifth that of the very large and tumid ventral dististyle, *vd*; setæ of latter virtually lacking on mesal face; rostral prolongation small, pointed at apex, with two rostral spines from a common tubercle or from two very closely approximated tubercles; spines subequal to one another, placed close together,

straight, tips relatively blunt. Gonapophyses, *g*, dark-colored, mesal-apical lobe very broad, its tip acute, margin microscopically and irregularly toothed. *Æ*deagus, *a*, relatively narrow, the two apical lobes separated by a narrow notch.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*). Paratopotype, male, pinned with type.

Most generally similar to *Limonia* (*Geranomyia*) *suensoniana* Alexander, of eastern China, and to *L. (G.) radialis* Alexander, ranging from southern Japan to western China, especially in the great length of vein Sc and the basal position of m-cu. It differs in the details of pattern of the thorax and wings and especially in the structure of the male hypopygium, notably the very large ventral dististyle, the pointed apex of the rostral prolongation, and the quite distinct conformation of the lobes of the gonapophyses.

HELIUS (HELIUS) FRANCKIANUS sp. nov. Plate 1, fig. 9; Plate 2, fig. 37.

Large (wing, male, 9 millimeters); general coloration dark gray; halteres uniformly pale yellow; legs yellow; wings brownish yellow, prearcular and costal fields conspicuously light yellow; a sparse darkened pattern, including stigma, wing tip, and clouds in axillary region; Sc long, Sc₁ ending beyond fork of Rs; Rs short, oblique, subequal in length to cell 1st M₂; m-cu close to fork of M; male hypopygium with inner dististyle long and slender, much exceeding short bispinous outer dististyle.

Male.—Length, about 10 millimeters; wing, 9; antenna, about 1.2.

Rostrum a little longer than remainder of head, black throughout; palpi black. Antennæ short, a little longer than rostrum; scape and pedicel black, flagellum brown; flagellar segments oval, passing through elongate oval to attenuate; terminal segment unusually long; verticils subequal in length to segments, on basal portion of flagellum unilaterally arranged. Head dark gray; anterior vertex a little wider than diameter of scape.

Cervical region black. Pronotum and mesonotum almost uniformly blackish gray, præscutal stripes not or scarcely evident. Pleura blackish gray, including dorsopleural membrane. Halteres uniformly pale yellow. Legs with coxæ pale, fore pair a little more darkened; trochanters yellow; femora bright yellow, tips not or scarcely darkened; remainder of legs bright yellow,

terminal tarsal segments darkened; claws simple. Wings (Plate 1, fig. 9) brownish yellow, prearcular and costal fields conspicuously light yellow; stigma oval, dark brown; a scarcely apparent brown seam on anterior cord; wing tip narrowly darkened; a brown seam along basal portion of vein Cu in cell M; axillary region weakly darkened; veins pale brown, clear luteous in clearer yellow areas. Venation: Sc long, Sc₁ ending beyond fork of Rs, Sc₂ at tip; Rs short, oblique, subequal in length to cell 1st M₂; branches of Rs weakly divergent at outer ends so cell R₃ is wider at margin than cell R₂; cell 1st M₂ subrectangular, shorter than veins beyond it; m-cu close to or just beyond fork of M.

Abdomen brownish black, hypopygium a trifle brightened. Male hypopygium (Plate 3, fig. 37) with lateral lobes of tergite, 9*l*, appearing as oval flattened plates, apex of each produced into a long straight spine. Basistyle, *b*, without lobes; setæ of narrowed apical portion elongate. Outer dististyle, *od*, short, glabrous, bispinous at apex. Inner dististyle, *id*, unusually long and slender.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*).

I take unusual pleasure in dedicating this fine species to the Reverend Mr. George Meredith Franck, to whose friendly interest and enthusiasm we owe much of our knowledge of the Tipulidæ of western China. This conspicuous fly is very distinct from all other species so far described from Asia.

ORIMARGA (ORIMARGA) GUTTIPENNIS sp. nov. Plate 1, fig. 10; Plate 3, fig. 38.

Very large (wing, male, over 7 millimeters); general coloration dark gray; antennæ black throughout; halteres pale yellow; legs brownish black; wings pale yellow, sparsely patterned with brown; costal fringe short; numerous macrotrichia on longitudinal veins beyond cord, with exception of R₂₊₃; free tip of Sc₂ distinct; R₂₊₃ longer than R₁₊₂; male hypopygium with basistyle simple.

Male.—Length, about 11 millimeters; wing, 7.6.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval to long-oval, verticils short. Head dark gray.

Mesonotum uniformly dark gray, præscutum without stripes. Pleura dark gray, vaguely striped longitudinally with paler on dorsal sternopleurite and ventral pteropleurite. Halteres pale yellow. Legs with the coxæ dark brown, posterior pair a little

paler; trochanters testaceous; remainder of legs brownish black, femoral bases a little paler. Wings (Plate 1, fig. 10) pale yellow, sparsely patterned with brown, including spots at origin and fork of Rs, fork of Sc, free tip of Sc₂, R₂, cord, fork of M₃₊₄, and m-cu; veins yellow, brown in clouded areas. Costal fringe short; macrotrichia on longitudinal veins beyond cord with exception of R₂₊₃. Venation: Sc₁ ending a short distance beyond fork of Rs, Sc₂ close to its tip; Rs angulated at origin; free tip of Sc₂ distinct, R₁ beyond it a little longer than R₂; R₁₊₂ long, subequal to vein Sc₂ + R₁; R₂₊₃ longer than R₁₊₂; basal section of R₄₊₅ angulated at origin; m-cu about opposite three-fourths length of Rs; vein 2d A long, cell wide.

Abdomen, including hypopygium, black. Male hypopygium (Plate 3, fig. 38) with basistyle, *b*, simple; interbases, *i*, appearing as blackened rods, tips narrowed into needlelike whitened points. Outer dististyle, *od*, a simple straight rod, tip gradually narrowed to a slightly decurved point. Inner dististyle a little shorter, entirely pale, with coarse setæ. Phallosome, *p*, appearing as two very slender divergent rods that bear an outer flange of almost hyaline membrane (the latter not shown in figure).

Habitat.—China (Szechwan).

Holotype, male, Mount Owei, Flying Bridges, altitude 3,000 feet, June 2, 1938 (*Tsen*).

Orimarga (*Orimarga*) *guttipennis* is very distinct from all described regional species of the genus by the unusually large size and spotted wings. By my key to the Chinese species of *Orimarga*³ it runs to the almost equally large *O. (O.) latissima* Alexander, which is distinguished by the even wider, unpatterned wings and by the very different male hypopygium.

PEDICINI

DICRANOTA (RHAPHIDOLABIS) ANGUSTISTYLA sp. nov. Plate 1, fig. 11; Plate 3, fig. 39.

General coloration light gray; antennæ 15-segmented, segments stout and well-delimited; legs black, femoral bases obscure yellow; wings subhyaline, stigma pale brown; Rs relatively short; male hypopygium with tergite deeply bilobed, mesal angle of lobes with long setæ; interbase very large and complex in structure, at apex expanded into a multispinous head; both dististyles slender.

Male.—Length, about 6.5 millimeters; wing, 6.5.

³ Philip. Journ. Sci. 54 (1934) 327.

Rostrum and palpi black. Antennæ black throughout, 15-segmented; flagellar segments stout and well-delimited, terminal segment reduced; flagellar segments with abundant white pubescence. Head gray.

Mesonotum light gray, præscutum apparently with darker stripes, but badly discolored in unique type. Halteres with stem pale, knob darkened. Legs with coxæ dark; trochanters brownish testaceous; remainder of legs black, femoral bases obscure yellow. Wings (Plate 1, fig. 11) subhyaline, stigma pale brown; veins brown. Venation: Rs relatively short, arcuated; R_{2+3+4} longer than basal section of R_5 ; m-cu more than one-half its length beyond fork of M.

Abdomen brownish black; hypopygium black. Male hypopygium (Plate 3, fig. 39) with tergite, 9t, deeply bilobed, lobes separated by a very deep U-shaped notch, opening of notch slightly narrower than base; lobes broad, outer mesal angle rounded and provided with abundant long setæ. Interbase, *i*, very large and complex in structure, at apex expanded into a multispinous head, one spine much longer and larger than the others. Both dististyles very slender, the outer, *od*, dusky, weakly sinuous, clothed with conspicuous setæ. Inner dististyle, *id*, a long narrow yellow blade, at base produced into a narrow lobe.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*).

Dicranota (*Rhaphidolabis*) *angustistyla* is very different from all other regional species of the subgenus having the tergite of the male hypopygium deeply lobed, as *D. (R) biloba* Alexander and *D. (R.) præcisa* Alexander. The species is well distinguished by the narrow elongate dististyles and especially by the complex spinous interbases.

HEXATOMINI

LIMNOPHILA (LIMNOPHILA) FENESTRELLA sp. nov. Plate 1, fig. 12; Plate 3, fig. 40.

General coloration dark brown; antennæ with scape black, basal flagellar segments yellow; legs light yellow; wings pale yellow, variegated with five crossbands that consist of a darkened center surrounded by a narrower brown border that is separated from the center by a narrow line of the ground color; cell M_1 long, m short to very short; male hypopygium with tip of outer dististyle a simple acute point; gonapophyses appearing as flattened spatulate blades.

Male.—Length, about 6.5 millimeters; wing, 7.

Rostrum and palpi black. Antennæ with scape black, pedicel brown; basal flagellar segments subglobular to short-oval, yellow; outer segments somewhat darker, passing into oval, with long conspicuous verticils. Head dark grayish brown; anterior vertex broad.

Mesonotum uniformly dark brown, without stripes or other markings. Pleura black, sparsely pruinose. Halteres pale. Legs with coxæ brownish black; trochanters obscure brownish yellow; remainder of legs light yellow; terminal tarsal segments broken. Wings (Plate 1, fig. 12) pale yellow, with a handsome, very conspicuous, crossbanded and ocellate brown pattern; five crossbands, fourth at cord, fifth apical; three basal bands before cord, first at arculus, third at level of origin of R_s ; all bands consisting of a central mark with a narrower brown border, separated from the main dark area by ground areas that are a little wider than the outer dark borders; basal three bands contiguous or confluent in cell M ; two outer bands nearly contiguous above fork of M_{1+2} ; all bands with pale centers in cell C ; a narrow but entire band of ground color before cord, separating third and fourth ocellate areas; veins yellow, darker where traversing brown bands. Venation: Sc_1 ending about opposite fork of R_s , Sc_2 near its tip; R_2 and R_{1+2} subequal; R_{2+3+4} a little shorter than basal section of R_s ; cell M_1 shorter than its petiole; m short to very short; in left wing of type M_3 connecting M_{1+2} with M_{3+4} before fork of M_3 ; $m-cu$ at near one-third length of cell 1st M_2 .

Abdomen brownish black, bases of segments a little brighter than tips; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 40) with basistyle, b , simple; setæ of mesal face long and erect. Outer dististyle slender, apex slightly decurved to a spinous point; before spine on lower face dilated into a weak flange. Inner dististyle, id , a short stout fleshy lobe. Gonapophyses, g , appearing as flattened spatulate blades, elongate heads with smooth margins. $\mathcal{A}$ edeagus strongly bent before tip, subtended beneath by pale membrane.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*).

Most closely related to *Limnophila* (*Limnophila*) *aino* Alexander, of northern Japan, and *L. (L.) dicranophragmoides* Alexander, of the Riukiu Islands, differing especially in the venation and the nature of the wing pattern.

LIMNOPHILA (PRIONOLABIS) LICTOR sp. nov. Plate 1, fig. 13; Plate 3, fig. 41.

Very small (wing, male, under 5 millimeters); mesothorax polished black; basal flagellar segments obscure yellow; head dark gray; legs yellow, tips of femora, tibiae, and basitarsi darkened; wings yellow, diffusely but extensively patterned with brown; R_{2+3+4} a little longer than basal section of R_5 ; cell M_1 lacking; male hypopygium with gonapophyses blackened, appearing as stout rods, at apex expanded into subcircular heads, margin with about eleven retrorse teeth.

Male.—Length, about 4.5 millimeters; wing, 4.8.

Rostrum and palpi black. Antennae with scape and pedicel black; basal flagellar segments obscure yellow, outer segments darker; flagellar segments oval, verticils slightly longer than segments. Head dark gray.

Mesothorax polished black unvariegated, dorsal pleurites a trifle more pruinose. Halteres with stem obscure yellow, knob broken. Legs with coxae blackened; trochanters obscure yellow; femora yellow, tips rather narrowly (about distal eighth) but conspicuously blackened, the amount subequal on all legs; tibiae and basitarsi yellow, tips more narrowly blackened; remainder of tarsi brownish black. Wings (Plate 1, fig. 13) with the ground color yellow, clearer yellow in prearcular and costal fields; stigma brown; an extensive but very diffuse paler-brown pattern appears as broad crossbands at level of arculus, origin of R_s and cord; apical cells slightly more infumed than ground; veins brown, yellow in luteous areas. Venation: Sc_1 ending about opposite fork of R_s , Sc_2 near its tip; R_s long, subequal in length to its anterior branch; R_{2+3+4} a little longer than basal section of R_5 ; cell M_1 lacking; m-cu at near one-third length of cell 1st M_2 .

Abdomen including hypopygium, black. Male hypopygium (Plate 3, fig. 41) with caudal border of tergite, $9t$, with a broad U-shaped notch, lobes glabrous and obtuse. Outer dististyle, od , with more than basal half dilated and with conspicuous setae, apex narrowed into a slender spinous blade. Inner dististyle, id , with base slightly swollen and setiferous, apex prolonged into a long slender yellow blade that is subequal in length and size to the beak of the outer style but with the apex more obtuse. Gonapophyses, g , blackened, appearing as stout rods, at apex expanded into subcircular heads, margin with about eleven retrorse teeth. Aedeagus, a , only feebly dilated, apex decurved.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*).

Limnophila (*Prionolabis*) *lictor* is very different from the other known regional species of the subgenus having cell M_1 of the wings lacking. The strongly darkened gonapophyses, with expanded macelike head, are quite different from that of all other species.

LIMNOPHILA (PRIONOLABIS) POLIOCHROA sp. nov. Plate 1, fig. 14; Plate 4, fig. 42.

General coloration dark gray, thorax without markings; halteres yellow; femora yellow, tips abruptly blackened, the amount subequal on all legs; wings brownish yellow, restrictedly patterned with brown; cell M_1 lacking; m-cu at or before midlength of cell 1st M_2 ; abdomen black; male hypopygium with gonapophyses appearing as long, slender, simple, gently curved, black rods, tips narrow and subacute, set with microscopic denticles.

Male.—Length, about 6 millimeters; wing, 6.5.

Female.—Length, about 6 to 6.5 millimeters; wing, 6.5 to 7.

Rostrum black, sparsely pruinose; palpi black. Antennæ of moderate length, black, flagellum a little paler, scape pruinose; flagellar segments oval. Head heavily light gray pruinose.

Thorax uniformly dark gray, unpatterned. Halteres yellow, base of stem a little more infuscated. Legs with coxæ dark gray; trochanters black; femora yellow, tips rather narrowly and abruptly blackened, the amount subequal on all legs and including about the distal sixth or seventh; tibiæ obscure yellow, tips blackened; basitarsi brown, remaining tarsal segments passing into black. Wings (Plate 1, fig. 14) brownish yellow, prearcular region clearer yellow; a restricted darker-brown pattern, as follows: origin of R_s , stigma, cord, and axillary region; less evident darkenings at outer end of cell 1st M_2 and along vein Cu; veins pale brown, a little darker in clouded portions, more luteous in yellow areas. Venation: Sc_1 ending about opposite or slightly before fork of R_s , Sc_2 a short distance from its tip; $R_{2,3+4}$ shorter than basal section of R_5 ; R_2 and R_{1+2} subequal; cell M_1 lacking; m-cu at or before midlength of lower face of cell 1st M_2 .

Abdomen black, including hypopygium; valves of ovipositor horn yellow. Male hypopygium (Plate 4, fig. 42) with caudal margin of tergite, 9t, with a broad U-shaped notch, lobes triangular in outline. Outer dististyle, *od*, moderately chitinized, basal portion weakly expanded, with long setæ; apex flattened

into a blade, terminating in a small decurved point. Inner dististyle, *id*, with base dilated, provided with coarse setæ, the long blackened beak simple, nearly straight, tip subacute. Gonapophyses, *g*, appearing as long, slender, simple, gently curved, black rods, tips narrow and subacute, set with microscopic denticles.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Hwa Nien Pin Temple, altitude 6,500 feet, June 15, 1938 (*Tsen*). Allotopotype, female. Paratopotype, 1 female.

Limnophila (*Prionolabis*) *poliochroa* is very different from the other species of the subgenus in eastern Asia having the body coloration gray and cell M_1 of the wings lacking. The most evident specific characters are to be found in the structure of the male hypopygium, especially the gonapophyses.

LIMNOPHILA (ADELPHOMYIA) SIMPLICISTYLA sp. nov. Plate 1, fig. 15; Plate 4, fig. 43.

General coloration medium brown, præscutum subnitidous, without distinct stripes; basal flagellar segments yellow; halteres pale; legs yellow, terminal tarsal segments infuscated; wings strongly tinged with brownish yellow; sparse macrotrichia in outer ends of cells R_3 to M_4 , with exception of R_4 ; $R_{2,3}$ and $R_{1,2}$ subequal in length, R_2 very faintly indicated; cell M_1 about twice its petiole; m-cu at near midlength of cell 1st M_2 ; male hypopygium with outer dististyle long and slender, black, apex bifid; inner dististyle simple; gonapophyses appearing as angular hooks.

Male.—Length, about 5 millimeters; wing, 5.5; antenna, about 1.5.

Rostrum ochreous; palpi light brown. Antennæ of moderate length; scape and pedicel brownish yellow, flagellum light yellow, outer segments darker; flagellar segments with conspicuous verticils that exceed segments in length. Head pale brown, pruinose.

Pronotum yellowish brown. Mesonotum almost uniformly medium brown, præscutum subnitidous, without distinct stripes. Pleura brown. Halteres pale. Legs yellow, terminal tarsal segments infuscated. Wings (Plate 1, fig. 15) strongly tinged with brownish yellow; stigma scarcely darker; veins and macrotrichia brown. Sparse macrotrichia in outer ends of cells R_3 to M_4 , inclusive, with exception of cell R_4 (indicated in figure by

stippling). Venation: Sc moderately long, Sc₁ ending a short distance before fork of Rs, Sc₂ a short distance from its tip; R₂ very pale to subobsolete; R₂₊₃ subequal to R₁₊₂; cells beyond cord relatively deep, especially cells R₃ and M₁; veins comprising anterior cord in transverse alignment; r-m arcuated; cell M₁ nearly twice as long as its petiole; cell 1st M₂ rectangular, with m-cu at near midlength.

Abdomen light brown; hypopygium yellow. Male hypopygium (Plate 4, fig. 43) with caudal margin of tergite transverse or feebly emarginate, without lobes. Outer dististyle, *od*, long and slender, blackened, outer portion strongly curved and narrowed, apex unequally bifid. Inner dististyle, *id*, shorter than outer, simple, lower face with abundant long setæ. Interbases, *i*, appearing as short plates, tips obtusely rounded. Gonapophyses appearing as strongly angulate hooks, the long points decussate across ædeagus.

Habitat.—China (Szechwan).

Holotype male, Mount Omei, Hwa Nien Pin Temple, altitude 6,500 feet, June 15, 1938 (*Tsen*).

I am referring this fly to the subgenus *Adelphomyia* Bergroth (*Tricholimnophila* Alexander) because of the structure of the antennæ and presence of macrotrichia in the outer wing cells. It differs from the other known species of the subgenus in the structure of the male hypopygium, notably the simple inner dististyle.

ELEPHANTOMYIA INSOLITA sp. nov. Plate 1, fig. 16.

General coloration dull black; rostrum unusually long, subequal to either body or wing; fore femora extensively blackened, posterior femora with tips narrowly darkened; all tibiæ and tarsi yellow; wings yellowish brown, unmarked except for a slightly darker brown stigma.

Female.—Length, excluding rostrum, about 9 millimeters; wing, 9; rostrum, about 9.

Rostrum brown, of unusual length, about equal in length to remainder of body or wing. Antennæ with scape and pedicel black, flagellum brown; flagellar segments cylindrical, outer segments more elongate; basal segment of flagellum more than one and one-half times as long as second; first and third subequal; terminal segment nearly as long as penultimate. Head light gray; eyes large; vertex reduced to a narrow stripe that is a little less than diameter of scape.

Thorax uniformly black, with a gray pruinosity to produce a plumbeous appearance; dorsopleural membrane restrictedly obscure yellow. Halteres brownish yellow, base of stem somewhat clearer yellow. Legs with coxæ yellow, fore pair a little darkened; trochanters yellow; femora obscure yellow basally, passing into brownish black, the latter very broadly so on fore and middle legs, on posterior legs tips narrowly darkened; tibiæ slightly infumed basally, soon passing into yellow; tarsi yellow; tibial spurs lacking; claws simple. Wings (Plate 1, fig. 16) strongly tinged with yellowish brown, prearcular field restrictedly yellow; stigma long-oval, pale brown, only a little darker than ground; veins pale brown. Venation: Sc_1 ending opposite fork of Rs , Sc_2 a little longer, near its tip; Rs relatively short, less than cell 1st M_2 , angulated and short-spurred at origin; branches of Rs generally parallel to one another; m-cu shortly beyond midlength of cell 1st M_2 ; cell 2d A relatively narrow.

Abdomen, including genital shield, black; valves of ovipositor horn-yellow, hypovalvæ blackened at bases.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*).

The nearest ally of the present fly is *Elephantomyia carbo* Alexander, likewise from the mountains of western China, differing especially in the polished black thorax, darkened tibiæ, and conspicuously patterned wings.

ERIOPTERINI

LIPSOTHRIX MIRABILIS sp. nov. Plate 1, fig. 17; Plate 4, fig. 44.

General coloration polished black; antennæ (male) elongate; legs black, terminal tarsal segments somewhat paler; wings yellowish brown, conspicuously patterned with darker brown, including costal border and broad seams along cord, outer end of cell 1st M_2 , and vein Cu; R_{2+3+4} suberect, unusually short, less than basal section of R_5 ; Rs long, subequal to vein R_4 ; male hypopygium with interbases unusually long and slender, at near midlength bent into a right angle, tip acute.

Male.—Length, about 9 millimeters; wing, 9.5; antenna, about 3.5.

Rostrum and palpi black. Antennæ black throughout, elongate (male) as shown by measurements; flagellar segments subcylindrical, verticils shorter than segments; terminal segment about one-third penultimate. Head black, heavily pruinose, especially on broad anterior vertex.

Thorax polished black, notum glabrous. Halteres with stem pale, knob weakly darkened. Legs with coxæ polished black; trochanters abruptly yellow; remainder of legs black, femoral bases very narrowly yellow, outer tarsal segments paling to brown; claws conspicuously toothed, including a larger spine before midlength and a smaller, more basal one. Wings (Plate 1, fig. 17) yellowish brown, conspicuously patterned with darker brown, including cells C and Sc, and seams on R_2 , R_{1+2} , cord, and outer end of cell 1st M_2 , with a longitudinal seam along vein Cu; outer radial field more vaguely darkened; veins beyond cord, as well as posterior wing margin, indistinctly clouded; posterior prearcular field clear yellow; veins brown, more yellowish in the more basal unclouded portions. Macrotrichia of veins relatively long and conspicuous on veins beyond cord, less numerous elsewhere, including a few on outer ends of Rs and 2d A. Venation: Sc long, Sc_1 ending beyond fork of R_{2+3+4} , Sc_2 at its tip; Rs long, subequal to R_4 ; R_{2+3+4} unusually short and suberect, less than basal section of R_5 ; cell M_1 lacking; cell 1st M_2 relatively large, subrectangular, with oblique m-cu at near one-fourth its length.

Abdomen, including hypopygium, black. Male hypopygium (Plate 4, fig. 44) of normal structure; inner dististyle, *id*, longer than outer, *od*, pointed at tip. Interbase, *i*, long and slender, bent at right angle at near midlength, tip acute.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, June 7, 1938 (*Tsen*).

Lipsothrix mirabilis is entirely different from all species of the genus hitherto made known. It is most similar to *L. pluto* Alexander, of the higher mountains of Formosa, which has a similarly blackened thorax and elongate antennæ in the male sex. The present fly differs conspicuously in the patterned wings and in the venation, as the unusually short R_{2+3+4} . In its general appearance the fly suggests species of *Limnophila* belonging to the subgenus *Prionolabis* Osten Sacken. It is the first species of *Lipsothrix* to be reported from China.

GNOMYIA (IDIOCERA) MULTIARMATA sp. nov. Plate 1, fig. 18; Plate 4, fig. 45.

General coloration gray, præscutum with two intermediate brown stripes; legs obscure yellow; wings brownish yellow, restrictedly patterned with darker brown, including stigma, wing tip and restricted seams at origin of Rs, cord and m-cu; Sc short, Sc_1 ending about opposite one-fifth length of Rs; male

hypopygium with all three dististyles bearing conspicuous branches; ædeagus elongate, simple.

Male.—Length, about 5 millimeters; wing, 5.

Rostrum and palpi black. Antennæ with basal segments yellow; flagellar segments beyond first black; basal flagellar segments subcylindrical, outer segments more fusiform, with truncated ends. Head gray.

Pronotum light gray. Mesonotal præscutum gray, humeral and lateral portions pale yellow; two intermediate brown stripes that are more expanded behind, interspace more obscured; pseudosutural foveæ pale; scutum with lobes grayish brown; scutellum dark brown, sparsely pruinose, caudal margin obscure yellow; mediotergite dark gray. Pleura dark gray, with a conspicuous, pale, longitudinal stripe involving dorsal sternopleurite, continued caudad and becoming more expanded behind, reaching base of abdomen; dorsopleural membrane pale. Halteres with stem yellow, knob weakly darkened. Legs with coxæ and trochanters yellow; remainder of legs brownish yellow to obscure yellow, outer tarsal segments darker. Wings (Plate 1, fig. 18) tinged with brownish yellow, restrictedly patterned with darker brown, including stigma; conspicuous wing tip in outer ends of cells R_3 and R_4 ; small seams at origin of R_s , cord, and m-cu; veins yellow, dark brown in clouded areas. Venation: Sc relatively short, Sc_1 ending about opposite one-fifth length of R_s , Sc_2 opposite origin of latter; R_3 moderately oblique, distance on margin between R_{1+2} and R_3 about one-third length of latter; m-cu a little more than its own length before fork of M .

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 4, fig. 45) with apical lobe of basistyle, *b*, elongate. Outer dististyle, *od*, a slender rod terminating in an acute point, on outer margin at near one-third length bearing a long strong spine; shortly before apex with a much smaller appressed spine. Intermediate dististyle, *md*, elongate, bifid, longest arm a flattened, twisted ribbon, longer than other elements of styli; at near midlength the style bears a small curved lateral arm. Inner dististyle, *id*, deeply bifid, outer arm a longer, gently curved spine; inner arm a straight spinous rod, tip acute, near apex with a few setæ. Ædeagus, *a*, elongate, simple, slender.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*).

Gonomyia (Idiocera) multiarmata is entirely different from other, now numerous, species of the subgenus in eastern Asia. It is well distinguished by the patterned wings and the unusual armature of the male hypopygium, especially the strongly bifid inner dististyle.

ERIOPTERA (TELENEURA) PERLUGUBRIS sp. nov. Plate 1, fig. 19.

General coloration black, including palpi, antennæ, and halteres; wings strongly blackened; Rs relatively long, about twice length of R_{2+3+4} ; abdomen black; ovipositor with strongly up-curved cerci horn-yellow.

Female.—Length, about 5 millimeters; wing, 5.8.

Rostrum and palpi black. Antennæ black, outer flagellar segments paling to dark brown; flagellar segments passing through oval to elongate. Head black.

Thorax uniformly black. Halteres black, base of stem restrictedly obscure yellow. Legs with coxæ blackened; trochanters testaceous yellow; remainder of legs obscure yellowish brown, with a vestiture of still darker setæ and linear scales; tarsi dark. Wings (Plate 1, fig. 19) relatively long and narrow, strongly blackened; veins and trichia still darker. Venation: Rs relatively long, about twice R_{2+3+4} , cells beyond cord long and narrow, as in subgenus.

Abdomen black; ovipositor with strongly upcurved cerci horn-yellow.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1933 (*Tsen*).

Erioptera (Teleneura) perlugubris is entirely distinct from the other described Chinese species, differing especially in the black coloration of the body and the darkened tarsi. It is most similar to the subgenotype, *E. (T.) fusca* de Meijere, of the Austramalayan islands, which differs in the much smaller size and the different venation, Rs being subequal in length to R_{2+3+4} .

ERIOPTERA (EMPEDA) BRACHYCLADA sp. nov. Plate 1, fig. 20; Plate 4, fig. 46.

General coloration light gray; antennæ black; halteres uniformly pale yellow; femora and tibiæ brownish yellow, tips a little darkened; no scales on legs; wings very pale yellow, especially basal and costal portions; veins yellow, brown in darker outer portions; stigma pale brownish yellow; Rs relatively short, subequal to R_4 ; abdomen, including hypopygium, black; male

hypopygium with stem of outer dististyle unusually short, outer arm shorter than inner, appearing as a curved spine, tip acute; inner arm expanded at apex; inner dististyle pale, at apex dilated into a high glabrous crest.

Male.—Length, about 4.2 to 4.5 millimeters; wing, 4.6 to 5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval. Head dark gray.

Thorax light gray, præscutum without stripes. Pleura gray, dorsopleural region only restrictedly brightened. Halteres uniformly pale yellow. Legs with coxæ reddish brown; trochanters obscure yellow; femora and tibiæ brownish yellow, tips a little darkened; tarsi dark brown to brownish black; legs without scales. Wings (Plate 1, fig. 20) very pale yellow, prearcular and costal fields paler and clearer yellow; cells beyond cord and anal field a little more darkened, best evidenced by darker veins, those in basal portions clear light yellow, including most of Rs; stigma pale brownish yellow. Venation: Sc of moderate length, Sc₁ ending opposite or just beyond midlength of Rs, Sc₂ somewhat variable in position, in cases at near middistance between origin of Rs and tip of Sc₁, in other specimens lying more distad; Rs relatively short, subequal to vein R₄; R₃ oblique, m-cu close to fork of M.

Abdomen, including hypopygium, black. Male hypopygium (Plate 4, fig. 46) with stem of outer dististyle, *od*, unusually short; outer arm shorter than inner, appearing as a curved spine, tip acute, inner or concave edge with a low flange; inner arm expanded at apex. Inner dististyle, *id*, pale, at apex dilated into a high glabrous crest.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, summit, altitude 10,800 to 11,000 feet, June 16, 1938 (*Tsen*). Paratopotype, several males, May 26 to June 16, 1938 (*Tsen*).

Erioptera (*Empeda*) *brachyclada* is most similar to *E. (E.) sulfureoclavata* Alexander, differing especially in the blackened hypopygium with the details of structure distinct. *E. (E.) nigrostylata* Alexander has numerous flattened scales on the legs, and the structure of the male hypopygium quite distinct.

ERIOPTERA (EMPEDA) FUSCOCINCTA sp. nov. Plate 1, fig. 21; Plate 4, fig. 47.

Large (wing, male, over 5 millimeters); general coloration clear gray; legs brownish black, without scales; wings tinged with yellow, with a broad brown seam along cord; Sc relatively long, Sc₁ ending beyond four-fifths length of long Rs; R₃ lon-

gitudinal in position; male hypopygium with outer dististyle darkened, deeply bifid, both arms obtuse at tips; gonapophyses appearing as broad pale plates.

Male.—Length, about 5 millimeters; wing, 5.4.

Rostrum and palpi black. Antennæ with scape black, succeeding segments dark brown; basal flagellar segments long-oval, outer segments more elongate and attenuate. Head gray.

Mesonotal præscutum gray, præscutum with poorly indicated pale-brown stripes; scutal lobes weakly darkened. Pleura clear gray. Halteres light orange yellow. Legs brownish black, coxæ pruinose; legs without scales. Wings (Plate 1, fig. 21) tinged with yellow, basal portions even brighter; stigma and a broad confluent seam on cord brown; extreme wing tip infumed; veins pale brown, more yellowish in basal portions. Venation: Sc relatively long, Sc₁ ending beyond four-fifths length of long Rs, Sc₂ a short distance from its tip; R₂₊₃₊₄ a trifle longer than R₂; R₃ longitudinal in position; m-cu at or immediately before fork of M.

Abdomen, including hypopygium, black, pruinose. Male hypopygium (Plate 4, fig. 47) with basistyle terminating in two lobes, stouter lobe with long setæ that equal or exceed the dististyle in length; second lobe smaller, with abundant dense setulæ and a very few long terminal setæ. Outer dististyle, *od*, darkened, deeply bifid, stem subequal in length to longest arm; one arm a little longer than the other, tips of both broadly obtuse. Inner dististyle, *id*, a simple blade, gradually narrowed to subacute tip, surface with several microscopic punctures. Gonapophyses, *g*, appearing as unusually broad and flattened pale plates.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Flying Bridges Temple, altitude 3,000 feet, June 1, 1938 (*Tsen*).

Erioptera (Empeda) fuscocincta is readily told from all other regional species of the subgenus by the conspicuously banded wings.

ORMOSIA (ORMOSIA) SUBDUCALIS sp. nov. Plate 1, fig. 22.

Allied to *ducalis*; large (wing, female, over 6.5 millimeters); general coloration black, including antennæ and legs; halteres orange yellow; wings brownish yellow, base clearer yellow; a restricted brown pattern, including stigma, a broad seam entire length of vein Cu, cord and base of vein M₃; cell M₂ open by

atrophy of m ; ovipositor with cerci short, strongly upcurved, black at base, tips horn-yellow.

Female.—Length, about 6 to 6.5 millimeters; wing, 7 to 7.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval. Head gray; anterior vertex broad.

Thorax black throughout. Halteres orange yellow. Legs black, extreme bases of femora more brightened. Wings (Plate 1, fig. 22) brownish yellow, base clearer yellow; stigma more infuscated; a broad dusky seam entire length of veins Cu and Cu_1 ; more restricted dark clouds on cord and along vein M_3 ; veins pale brown, more yellowish in brightened basal portions. Macrotrichia of wing cells abundant, in all cells beyond arculus with exception of base of Sc (shown in figure by stippling). Venation: Sc_2 far from tip of Sc_1 , about opposite one-fifth length of long straight Rs ; R_2 subequal to R_{2+3} ; cell M_2 open by atrophy of m ; cell M_3 moderately deep, its petiole and $m-cu$ subequal; $m-cu$ at fork of M ; vein 2d A nearly straight.

Abdomen black, including genital shield and bases of short, strongly upcurved cerci, tips of the latter horn-yellow.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, White Cloud Temple, altitude 9,000 feet, May 25, 1938 (*Tsen*). Paratype, female, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, August 5, 1935 (*Graham*); U. S. Nat. Mus.

The nearest described ally is *Ormosia* (*Ormosia*) *ducalis* Alexander, of northern Korea, which has the same general size, coloration, and venation, differing especially in the uniformly darkened wings, with slight differences in venation, especially in the shorter veins, R_{2+3+4} and M_{3+4} .

ORMOSIA (ORMOSIA) INÆQUISPINA sp. nov. Plate 1, fig. 23; Plate 4, fig. 48.

Belongs to the *similis* group; general coloration dark brown; antennæ (male) elongate, exceeding one-half length of body; flagellar segments fusiform, with conspicuous, erect, dark-colored setæ; wings with a brownish tinge, stigma darker; vein 2d A sinuous; male hypopygium with gonapophyses appearing as long, slender, curved spines, on outer margin beyond base bearing a long, slender, nearly straight spine.

Male.—Length, about 4 millimeters; wing, 4.7; antenna, about 2.5.

Rostrum dark brown; palpi black. Antennæ black throughout, elongate, if bent backward extending to beyond base of abdomen; flagellar segments fusiform, with conspicuous, erect,

dark-colored setæ that are subequal to length of segments. Head dark brown.

Thorax dark brown, pleura sparsely pruinose. Halteres dusky, with golden-yellow setæ. Legs with coxæ dark brown; trochanters testaceous; remainder of legs dark brown. Wings (Plate 1, fig. 23) with a brown tinge, stigma darker brown; veins pale brown. Macrotrichia of cells abundant (indicated in figure by stippling). Venation: Sc_1 ending opposite or just beyond R_2 ; Rs relatively short, subequal to R_3 ; R_2 at fork of R_{2+3+4} ; cell M_2 open by atrophy of basal section of M_3 ; m-cu at fork of M ; vein 2d A sinuous.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 4, fig. 48) with both dististyles dusky; outer style, *od*, unusually small, oval in outline; inner style, *id*, prolonged into a slender apical point. Gonapophysis, *g*, appearing as long, slender, curved spines, blackened tips acute; on outer margin beyond base a long, slender, nearly straight, acute spine, entirely pale and about one-half as long as major axial apophysis.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*).

Ormosia (*Ormosia*) *inæquispina* is closest to *O. (O.) tenuispinosa* Alexander, which has somewhat similar antennæ in the male but the flagellar setæ pale and inconspicuous though long. The male hypopygium, especially the gonapophyses, is quite different in the two flies.

ORMOSIA (ORMOSIA) DECORATA sp. nov. Plate 1, fig. 24; Plate 4, fig. 49.

Belongs to the *similis* group; general coloration of thorax uniformly dark gray; antennæ (male) moderately long, if bent backwards extending to beyond wing root; femora brownish yellow basally, at near midlength passing into dark brown; wings yellow, heavily patterned with darker, including major areas at origin of Rs and on cord; cell M_2 open by atrophy of basal section of M_3 ; vein 2d A weakly sinuous on distal third; male hypopygium with outer gonapophysis a strongly bent rod, long apical portion gradually narrowed into a needlelike spine; inner gonapophysis shorter, very strongly curved, tip blackened and acute.

Male.—Length, about 4 millimeters; wing, 4.5; antenna, about 1.1.

Rostrum black, sparsely pruinose; palpi black. Antennæ moderately long, if bent backward extending to beyond wing

root, black throughout; flagellar segments long-oval, longest verticils much exceeding segments and unilaterally distributed; in addition to verticils, segments with a conspicuous white pubescence. Head dark gray.

Mesonotum uniformly dark gray, with yellow setæ; tuberculate pits black. Pleura black, gray pruinose. Halteres pale yellow. Legs with coxæ plumbeous; trochanters yellow; femora brownish yellow basally, at near midlength passing into dark brown; tibiæ and tarsi dark brown. Wings (Plate 1, fig. 24) with ground color yellow, heavily patterned with darker, including a major area at fork of Sc and origin of Rs, extending caudad virtually to vein M; stigma and a broad confluent seam on cord; smaller dark marginal clouds at ends of longitudinal veins, largest at 2d A; base of cell Cu and fork of M less distinctly clouded; veins yellow, infuscated in clouded portions. Numerous conspicuous macrotrichia in cells of wing (indicated in figure by stippling). Venation: Sc₁ ending a short distance beyond R₂, Sc₂ about opposite one-third to one-fourth length of Rs; R₂ subequal to R₂₊₃; cell M₂ open by atrophy of basal section of M₃; vein 2d A weakly sinuous on distal third.

Abdomen, including hypopygium, brownish black. Male hypopygium (Plate 4, fig. 49) with outer dististyle, *od*, relatively small and slender, the surface with rows of appressed spines, as in group. Inner dististyle, *id*, with apical beak moderately elongate. Outer gonapophysis, *og*, appearing as strongly bent rods, long apical portion very gradually narrowed into a needle-like spine. Inner gonapophysis, *ig*, shorter, very strongly curved, tip blackened and acute.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, White Cloud Temple, altitude 9,000 feet, June 6, 1938 (*Tsen*). Paratopotype, male, Hwa Nien Pin Temple, altitude 6,500 feet, June 15, 1938 (*Tsen*).

Ormosia (*Ormosia*) *decorata* is readily told by the conspicuously patterned wings, darkened legs, and, especially, the structure of the male hypopygium, notably of the gonapophyses. It superficially resembles *O. (O.) auricosta* Alexander and *O. (O.) beatifica* Alexander, but is entirely distinct.

MOLOPHILUS (MOLOPHILUS) TSENI sp. nov. Plate 4, fig. 50.

Belongs to the *gracilis* group and subgroup; general coloration of thorax black, præscutum dark reddish brown; halteres pale yellow; legs brownish black; wings with a yellowish-brown

tinge; male hypopygium with the dorsal lobe of basistyle divided into two points, one a nearly straight blackened spine, the other a broader flattened blade; ventral lobe of basistyle unusually small and slender; outer dististyle a glabrous curved hook from a dilated base; inner dististyle smaller, a simple sigmoid rod; phallosomic plate obtuse at apex, surface glabrous.

Male.—Length, about 4 millimeters; wing, about 4.6.

Rostrum and palpi black. Antennæ black throughout. Head dark gray.

Mesonotal præscutum dark reddish brown, contrasting with the black scutum, scutellum, postnotum, and pleura. Halteres pale yellow. Legs with coxæ and trochanters black; remainder of legs brownish black. Wings with a yellowish brown tinge; veins darker brown; trichia, including costal fringe, brownish black. Venation: R_2 lying shortly distad of level of r-m; petiole of cell M_3 more than three times m-cu; vein 2d A long, sinuous, ending about opposite midlength of petiole of cell M_3 .

Abdomen black, hypopygium, especially dististyles, a little brightened. Male hypopygium (Plate 4, fig. 50) with dorsal lobe of basistyle, *db*, terminating in two conspicuous points, one a nearly straight blackened spine, the other a little shorter and broader, appearing as a dusky flattened blade, apex obtuse; mesal lobe low and broad; ventral lobe, *vb*, unusually small and slender, with coarse retrorse setæ. Outer dististyle, *od*, a strongly curved, simple hook from a dilated base, distal half narrowed into a long spine, surface of style glabrous. Inner dististyle, *id*, a little shorter, appearing as a simple sigmoid rod, apical third a long straight spine, at point of flexure and on base of apical point with about fifteen setigerous punctures. Phallosomic plate, *p*, obtuse at apex, surface glabrous.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, Chu Lao Tong Temple, altitude 6,500 feet, June 6, 1938 (*Tsen*).

Molophilus (Molophilus) tseni is named in honor of the collector of this important series of Tipulidæ from Mount Omei, Mr. Tsen Bao-chi. It is readily told from allied generally similar black species by the brightened præscutum and by the structure of the male hypopygium, notably the bifid dorsal lobe of the basistyle, the unusually small and slender ventral lobe, and the conformation of the dististyles.

ILLUSTRATIONS

[Legend: *a*, Aedeagus; *b*, basistyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *ig*, inner gonapophysis; *md*, intermediate dististyle; *od*, outer dististyle; *og*, outer gonapophysis; *p*, phallosome; *s*, sternite; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

- FIG. 1. *Tipula* (*Nippotipula*) *brevifusa* sp. nov.; venation.
 2. *Tipula* (*Vestiplex*) *erectiloba* sp. nov.; venation.
 3. *Tipula* (*Vestiplex*) *factiosa* sp. nov.; venation.
 4. *Tipula* (*Oreomyza*) *sternosetosa* sp. nov.; venation.
 5. *Tipula* (*Oreomyza*) *incisurata* sp. nov.; venation.
 6. *Liogma simplicicornis* sp. nov.; venation.
 7. *Limonia* (*Dicranomyia*) *amplificata* sp. nov.; venation.
 8. *Limonia* (*Geranomyia*) *obesistyla* sp. nov.; venation.
 9. *Helius* (*Helius*) *francianus* sp. nov.; venation.
 10. *Orimarga* (*Orimarga*) *guttipennis* sp. nov.; venation.
 11. *Dicranota* (*Rhaphidolabis*) *angustistyla* sp. nov.; venation.
 12. *Limnophila* (*Limnophila*) *fenestrella* sp. nov.; venation.
 13. *Limnophila* (*Prionolabis*) *lictor* sp. nov.; venation.
 14. *Limnophila* (*Prionolabis*) *poliochroa* sp. nov.; venation.
 15. *Limnophila* (*Adelphomyia*) *simplicistyla* sp. nov.; venation.
 16. *Elephantomyia insolita* sp. nov.; venation.
 17. *Lipsothrix mirabilis* sp. nov.; venation.
 18. *Gonomyia* (*Idiocera*) *multiarmata* sp. nov.; venation.
 19. *Erioptera* (*Teleneura*) *perlugubris* sp. nov.; venation.
 20. *Erioptera* (*Empeda*) *brachyclada* sp. nov.; venation.
 21. *Erioptera* (*Empeda*) *fuscocincta* sp. nov.; venation.
 22. *Ormosia* (*Ormosia*) *subducalis* sp. nov.; venation.
 23. *Ormosia* (*Ormosia*) *inæquispina* sp. nov.; venation.
 24. *Ormosia* (*Ormosia*) *decorata* sp. nov.; venation.

PLATE 2

- FIG. 25. *Tipula* (*Vestiplex*) *erectiloba* sp. nov.; male hypopygium, lateral.
 26. *Tipula* (*Vestiplex*) *erectiloba* sp. nov.; male hypopygium, ninth tergite.
 27. *Tipula* (*Vestiplex*) *factiosa* sp. nov.; male hypopygium, ninth tergite.
 28. *Tipula* (*Vestiplex*) *factiosa* sp. nov.; male hypopygium, styli.
 29. *Tipula* (*Oreomyza*) *sternosetosa* sp. nov.; male hypopygium, lateral.
 30. *Tipula* (*Oreomyza*) *sternosetosa* sp. nov.; male hypopygium, details.
 31. *Tipula* (*Oreomyza*) *incisurata* sp. nov.; male hypopygium, lateral.
 32. *Tipula* (*Oreomyza*) *incisurata* sp. nov.; male hypopygium, ninth tergite.

PLATE 3

- FIG. 33. *Liogma simplicicornis* sp. nov.; antenna. male.
34. *Liogma simplicicornis* sp. nov.; male hypopygium.
35. *Limonia* (*Dicranomyia*) *amplificata* sp. nov.; male hypopygium.
36. *Limonia* (*Geranomyia*) *obesistyla* sp. nov.; male hypopygium.
37. *Helius* (*Helius*) *francianus* sp. nov.; male hypopygium.
38. *Orimarga* (*Orimarga*) *guttipennis* sp. nov.; male hypopygium.
39. *Dicranota* (*Rhaphidolabis*) *angustistyla* sp. nov.; male hypopygium.
40. *Limnophila* (*Limnophila*) *fenestrella* sp. nov.; male hypopygium.
41. *Limnophila* (*Prionolabis*) *lictor* sp. nov.; male hypopygium.

PLATE 4

- FIG. 42. *Limnophila* (*Prionolabis*) *poliochroa* sp. nov.; male hypopygium.
43. *Limnophila* (*Adelphomyia*) *simplicistyla* sp. nov.; male hypopygium.
44. *Lipsothrix mirabilis* sp. nov.; male hypopygium.
45. *Gonomyia* (*Idiocera*) *multiarmata* sp. nov.; male hypopygium.
46. *Erioptera* (*Empeda*) *brachyclada* sp. nov.; male hypopygium.
47. *Erioptera* (*Empeda*) *fuscocincta* sp. nov.; male hypopygium.
48. *Ormosia* (*Ormosia*) *inæquispina* sp. nov.; male hypopygium.
49. *Ormosia* (*Ormosia*) *decorata* sp. nov.; male hypopygium.
50. *Molophilus* (*Molophilus*) *tseni* sp. nov.; male hypopygium.

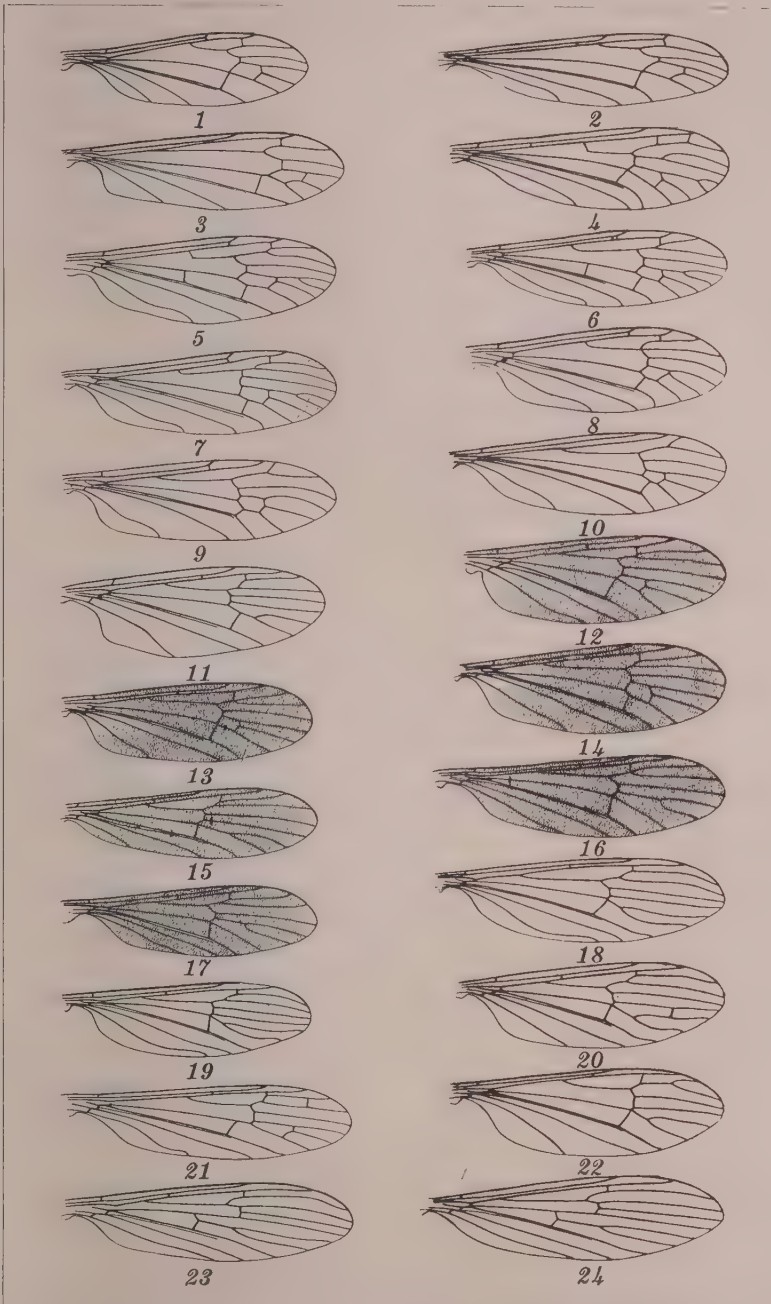


PLATE 1.

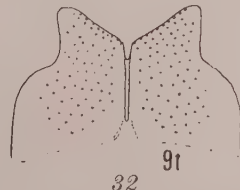
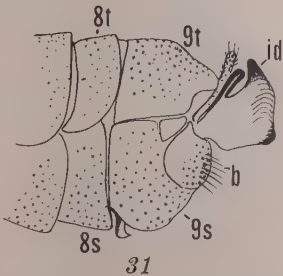
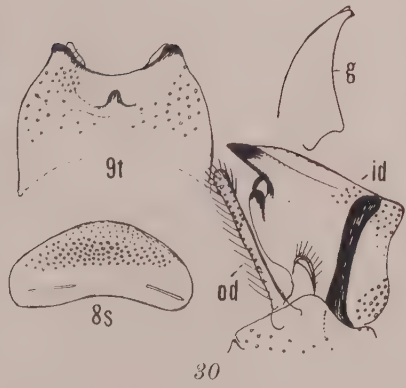
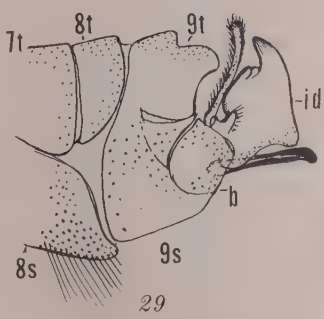
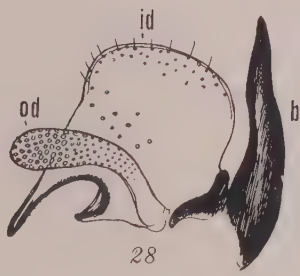
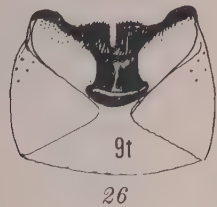
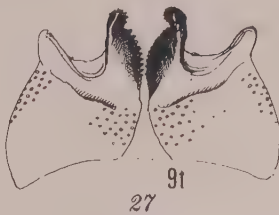
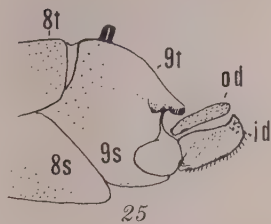
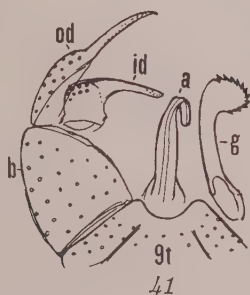
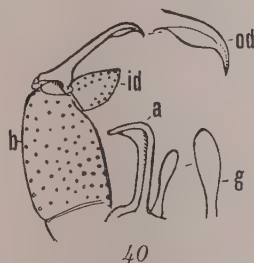
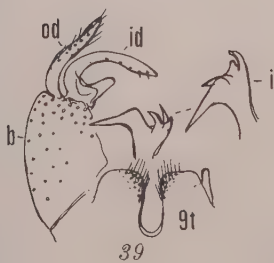
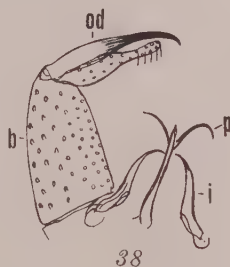
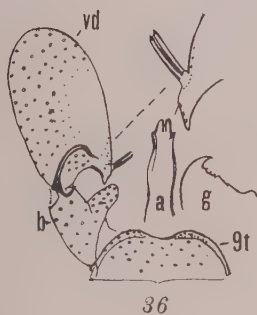
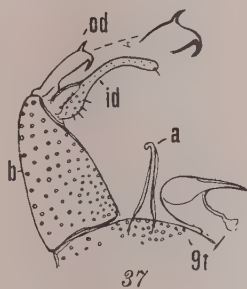
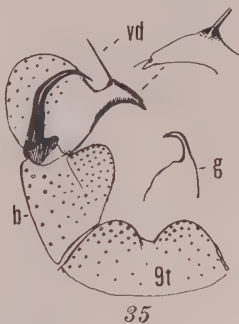
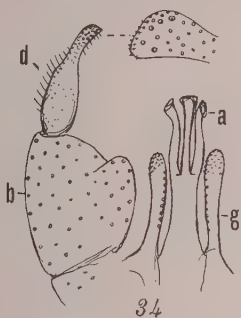
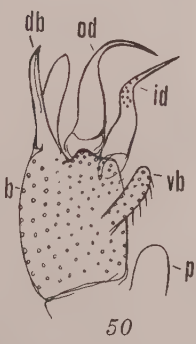
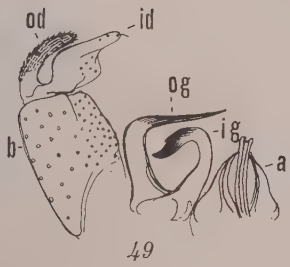
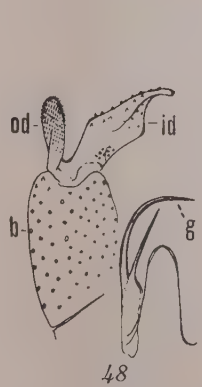
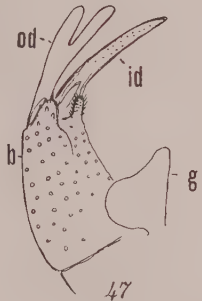
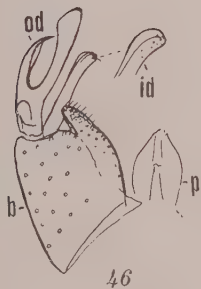
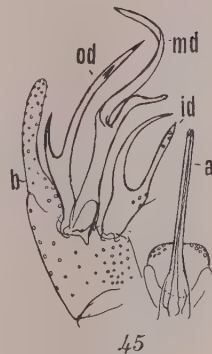
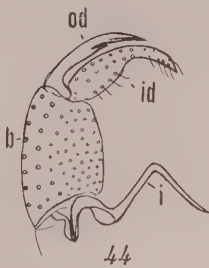
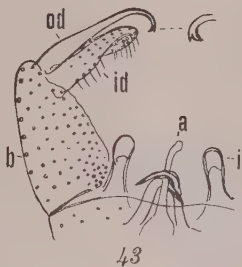
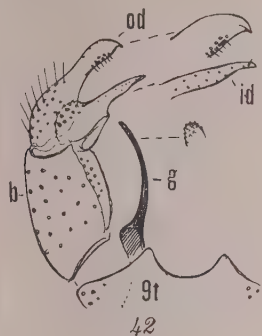


PLATE 2.





CERATOPOGONIDÆ AND CHIRONOMIDÆ FROM THE MICRONESIAN ISLANDS¹

WITH BIOLOGICAL NOTES BY TEISO ESAKI²

By MASAOKI TOKUNAGA

Of the Entomological Laboratory, Kyoto Imperial University, Japan

THREE PLATES

This report is based on a considerable collection made by Prof. Teiso Esaki in the Marianna, Caroline, and Marshall Islands during 1937 and 1938.

The collection consists of 12 species of Ceratopogonidæ (Heleidæ) and 9 species of Chironomidæ (Tendipedidæ). In 1936 I reported *Culicoides peliliouensis* as a biting midge from Palau Island, and at this time I intend to describe another blood-sucking midge, *C. esakii*, which also severely attacks men at Ponape Island, as the second species of troublesome biting midges from the Micronesia Islands. Two other species of the same genus are described and named here, *C. kusaiensis* and *C. ardentissimus*, respectively, but the blood-sucking habits of these species are not ascertained as yet. Three species of ectoparasitic midges, *Pterobosca adhesipes*, *P. esakii*, and *Lasiohelea pectinunguis*, are also dealt with in this paper. The species of *Pterobosca* were found clinging to the wings of dragon flies and sucking blood, piercing the veins of the wings. The third species was found sucking blood from a sphingid moth. Two other interesting midges are *Tanytarsus halophilæ* and *T. esakii*, the former reported as a marine species in 1926 from the Samoa Islands by Dr. F. W. Edwards. The latter species, newly named, is very closely allied to other known marine species, such as *T. halophilæ*, *T. maritimus*, *T. pontophilus*, and *T. magnihamatus*, in the reduction of the plumose hairs of the male antennæ, in the very small value of the antennal ratio of the

¹ Contribution from the Entomological Laboratory, Kyoto Imperial University, No. 81.

² Reports of Prof. T. Esaki's Micronesia Expeditions 1936-1938, No. 21.

male, and in the prolongation of the female cerci. These close morphological relations seem to suggest that the midge is marine in habitat.

The specimens of these Micronesian species are all alcoholic and deposited in the Entomological Laboratory, Kyusyu Imperial University. The morphological terminology used in the text is based on that of a number of my recent papers.

I am most grateful to Prof. Teiso Esaki, director of the Entomological Laboratory, Kyusyu Imperial University, for the opportunity of examining this interesting collection, and I take pleasure in thanking him not only for this privilege but also for many invaluable biological notes kindly furnished by himself in the text. I am also greatly indebted to Prof. Chukichi Harukawa, director of the Entomological Laboratory, Kyoto Imperial University, for his cordial help in the preparation of this report.

CERATOPOGONIDÆ

FORCIPOMYIA ESAKIANA sp. nov.

A beautiful species of moderate size, with yellow and dark markings.

Female.—Body 2.5 to 2.7 millimeters long; legs with many scales; wings darkly fumose, each with a black spot enveloping second radial cell and a large elongated white spot along costal margin beyond radial cells. Head and mouth parts dark brown. Antennæ brown, each with a double-headed stylet; basal segments longer than wide; antennal ratio about 1.4; proportional lengths of distal eight segments 19 : 19 : 19 : 40 : 42 : 40 : 40 : 49. Thorax almost entirely dark brown, dull, hairs yellow; mesoscutum somewhat paler along pseudosutural foveæ and on caudoscuteal area. Legs yellow, with scales, each with a dark-brown ring before and beyond knee joint; trochanters dark brown; femora pale yellow; tarsal segments entirely yellowish brown; middle and hind coxæ each with a dark-brown median ring; claws simple; tarsal ratio of hind leg about 0.47. Proportional lengths of segments of legs 34 : 35 : 11 : 15 : 8 : 6 : 5 in foreleg, 41 : 47 : 9 : 20 : 9 : 6 : 5 in middle leg, and 45 : 45 : 10 : 21.5 : 10 : 8 : 5.5 in hind leg. Wings (Plate 1, fig. 2) dark, each with a black spot covering second radial cell, a white large spot beyond end of costa, a faint paler spot covering r-m; intercalary fork in cell R_5 obscure. Venation: costa ending at middle of wing, first radial cell slitlike, second radial cell short and barely longer than first, bases of M_1 and M_2 atrophied,

fMCu under second radial cell. Halteres white. Abdomen with terga dark brown, pleural sides yellowish white and clothed with dark hairs, sternal side yellowish white and with a pair of lateral brown stripes throughout segments; cerci white.

Male.—Body about 3 millimeters long. Antennæ (Plate 1, fig. 12) with plumose hairs black; antennal ratio about 1.15; proportional lengths of distal six segments 23 : 24 : 90 : 58 : 45 : 54. Legs with trochanters all yellow, middle coxa brown, other coxæ yellow; claws slender, long, strongly arcuated, simple; proportional lengths of segments of hind leg 40 : 40 : 8 : 22 : 11 : 7.5 : 5; tarsal ratio of hind leg about 0.36. Wings (Plate 1, fig. 1) paler and narrower than in male, with anal area paler than other parts. Abdominal terga from first to fifth each subdivided into a pair of hemitergal plates. Hypopygium (Plate 1, fig. 15) black, without anal points; gonapophyses fused on basal half, bicuspidated and sharply pointed distally; styles almost as long as coxites, straight, pubescent on basal two-thirds, each with two blunt small teeth before distal end.

Locality.—Caroline Islands.

Holotype.—Male; Toloas-Erin, Truk Island; November 14, 1937.

Allotype.—Female, Malem, Kusaie Island; December 14, 1937.

Paratype.—Female, Malem, Kusaie Island; December 14, 1937.

This species is closely allied to *F. alboclavata* Kieffer, *F. hirtipes* de Meijere, and *F. biannulata* Ingram et Macfie. The first allied species, however, differs in the absence of scales on the legs and of white spots on the wings; the second species also differs in the absence of scales on the legs, and the third species is provided with a larger tarsal ratio of the hind leg, which is about 0.7.

LASIOHELEA PECTINUNGUIS de Meijere.

This ectoparasitic midge was first reported from Sumatra by Dr. J. C. H. de Meijere in 1923. The females were sucking blood from wings of *Mittochrista cruciata* Walker (arctiid) and *Simplicia margmata* Moore (noctuid). The specimens examined at this time were found on a sphingið moth collected at Kusaie. The male is unknown.

Female.—Body 1.2 to 1.5 millimeters long, wings about 1.1. Head including mouth parts brown, with eyes bare, broadly contiguous above. Maxillary palpi (Plate 1, fig. 16) 5-segmented (5 : 15 : 28 : 14 : 13); third segment very large, with sensillæ scattered on distal half of mesal side. Antennæ (Plate

1, fig. 7) with antennal ratio about 1.3; ultimate segment with a stylet pubescent; proportional lengths of distal eight segments 11 : 11 : 11.5 : 17.5 : 19 : 20 : 20.5 : 35. Thorax brown, slightly shining, with hairs yellow; mesoscutum with two pairs of yellowish-brown spots on anterior margin and with four brown subconfluent vittæ; caudoscuteal area pale brown; scutellum yellowish brown; postscutellum dark brown; thoracic pleural and sternal sclerites yellowish brown; membranous areas yellow. Legs yellowish brown, with scales on tibiæ and tarsi; fourth tarsal segments squarely thickened; tarsal ratio of hind leg about 2.78; claws (Plate 1, fig. 13) slender, strongly angulated, with asymmetrical basal teeth; empodium large. Proportional lengths of segments 19:19:10:3.5:3:2.7:2.9 in foreleg, 23:23:9.5:3.8:3.4:2.5:2.5 in middle leg, and 24:23:12.5:4.5:4:2.5:3.2 in hind leg. Wings (Plate 1, fig. 5) without colored markings, thickly hairy all over surface, with intercalary fork of cell R_5 distinct. Venation: Costa extending beyond middle of wing and slightly produced beyond end of R_s , first radial cell obliterated, second radial cell narrow and long, basal part of M_2 atrophied, fMCu slightly beyond base of second radial cell. Abdomen with tergal side pale brown, sternal plates yellowish brown, membranous areas yellow; cerci (Plate 1, fig. 21) discoidal, yellowish pale brown; spermathecae (Plate 1, fig. 22) two, unequal, brown, short-oval.

Specimens.—Females; Lelo, Kusaie Island, Caroline Islands; November 30, 1937.

LASIOHELEA CAROLINENSIS sp. nov.

A small yellowish-white species with wings unadorned.

Female.—Body 1 to 1.2 millimeters long, yellowish in ground color. Head including antennæ and mouth parts brownish yellow. Thorax yellow, dull; mesoscutum with four yellowish pale-brown vittæ. Abdomen yellowish white. Legs yellowish white. Halteres white.

Head with eyes bare, contiguous above. Maxillary palpi (Plate 2, fig. 42) 5-segmented (6 : 14 : 13 : 10 : 11); third segment with scattered sensillæ. Antennæ (Plate 2, fig. 43) each with a terminal stylet; antennal ratio about 1.6; proportional lengths of distal eight segments 9:9:10:19:21:22:21:27:5. Mesoscutum yellow, with four yellowish pale-brown vittæ, of which median vittæ are short and subconfluent; scutellum yellowish white; other thoracic sclerites all yellow. Legs with slender scales; claws simple; empodium as long as claws; tarsal

ratio of hind leg about 2; proportional lengths of segments of hind leg 22:22.5:12:6:4.5:3:2.2. Wings (Plate 1, fig. 6) densely clothed with macrotrichia, intercalary fork in cell R_5 distinct. Venation: Costa hardly extending two-thirds of wing and barely produced beyond end of R_s , first radial cell linear, second radial cell very narrow and longer than thrice first radial cell (77:21), R_1 about one-third of R_s (30:100), base of M_1 and M_2 atrophied, M_1 angulated at middle, fMCu beyond base of second radial cell. Abdominal terga pale brownish yellow; spermatheca (Plate 1, fig. 19) one, almost spherical.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Female; Lelo, Kusaie Island; November 21, 1937.

Paratypes.—Females: Lelo and Malem, Kusaie Island; November 21 and December 14, 1937.

This species is somewhat allied to *L. tawana* Shiraki, *L. cubitalis* Kieffer, *L. lefanui* var. *squamipes* Ingram et Macfie, *L. stimulans* de Meijere, and *L. villosa* Macfie, which, however, differ in the following points: In the first allied species the eyes are pubescent, the maxillary palpi are provided with sensory pores, the legs are not provided with scales, and the color of the body is dark. In the second species the distal five antennal segments are longer, each being about two and one-half times segment nine. In the third species the wings are provided with bare areas along veins, and the body is dark brown. In the fourth species the antennal ratio is about 1.9, and the wings also have bare areas along veins. In the fifth species the tarsal ratio of the hind leg is about 1.8 and the antennal ratio is about 2.65.

PTEROBOSCA ADHESIPES Macfie.

This ectoparasitic midge has been often recorded from the tropical islands of the Pacific Ocean. The following species of dragon flies have been known as the hosts of this midge: *Lestes præmorsus* Selys, *Orthetrum sabina* Drury, *O. chrysis* Selys, *Raphismia bispina* Hagen, *Hemicordulia silvarum* Ris, and *Agrionoptera insignis allogenes* Tillyard. The specimens examined this time were collected at Ponape and Kusaie. The male is unknown.

Female.—Body 1.6 to 1.7 millimeters long; wing about 1.2. Head black; mouth parts brown. Thorax dark brown, with pleural and sternal sclerites brown, pleural membranes yellow. Legs brown, knee joints dark brown; coxæ brown. Wings without colored markings. Halteres white. Abdomen with ter-

gal plates yellowish brown, sternal plates dark brown, membranous areas yellow.

Eyes bare, broadly contiguous above. Maxillary palpi (Plate 1, fig. 8) 5-segmented (8 : 11 : 13 : 9 : 10), each with a large shallow sensory pore furnished with short sensillae. Antennae (Plate 1, fig. 10) dark brown, each with a terminal nipplelike process; antennal ratio about 2.53; proportional lengths of distal eight segments as follows: 7.5 : 7.5 : 19 : 21 : 22 : 21 : 23 : 34. Mesoscutum black, with brown pubescence; caudoscuteal area brown, with a dark-brown median cloud. Legs without scales; tarsal ratio of hind leg varying from 3.5 to 4; fourth tarsal segments very short, usually shorter than half of fifth; tarsal claws absent; empodium very large, semicircular, with a pair of fleshy padlike lobes at base. Proportional lengths of segments as follows: 22 : 22 : 12.5 : 3 : 2 : 1.2 : 3.2 : in foreleg, 25 : 24 : 14 : 3.5 : 2.5 : 1.5 : 3 in middle leg, and 25 : 26 : 14 : 4 : 3 : 1.1 : 2.8 in hind leg. Wings (Plate 1, fig. 3) with macrotrichia thick; bare areas along veins distinct. Venation: Costa extending at middle of wing, first radial cell obliterated, second radial cell large and distinct, M_{1+2} forking just beyond r-m, but this forking is not clearly visible, the bases of two branches being deficient, fMCu under base of second radial cell. Abdominal segments from third to eighth each with sternal plate small, oval or cordiform; cerci (Plate 1, fig. 17) discoidal, dark brown; spermatheca (Plate 1, fig. 20) one, spherical, brown, with many hyaline scattered punctures.

Specimens.—Females; Kolonia-Nat, Ponape Island; November 19, 1937; Mwot-Utwe and Fwinkol, Kusaie Island; December 8 and 9, 1937.

PTEROBOSCA ESAKII sp. nov.

This ectoparasitic biting midge was found on the wings of dragon flies (Libellulidae). Male unknown.

Female.—Body 1.4 to 2 millimeters long; general coloration black, shiny. Wings about 1 millimeter long, unadorned, with second radial cell very small but distinct. Halteres dark brown.

Head with eyes bare, broadly contiguous above with each other. Antennae (Plate 1, fig. 11) dark brown; ultimate segment with a prominent terminal papillary projection; antennal ratio about 2.3; proportional lengths of distal eight segments 6 : 6 : 13 : 13 : 15 : 15 : 18 : 29. Maxillary palpi (Plate 1, fig. 9) 5-segmented (6 : 12 : 18 : 9 : 14); segment three with a sensory pore on distal part, its sensillae invisible externally.

Thorax black, slightly shiny, with pleural membranes yellow. Legs dark brown; fourth tarsal segment very narrow, obliquely truncated; segment five square, thick, with claws slender and strongly curved; empodium (Plate 1, fig. 14) very large, with twelve or thirteen radial lobes and two pairs of plumose hairlike lobes at base; femora and tibiae thickened; tarsal ratio of hind leg about 3.3. Proportional lengths of segments of legs 19 : 19 : 9 : 3 : 2 : 1.5 : 3 in foreleg, 22 : 22 : 10 : 3 : 2.5 : 1.5 : 3 in middle leg, and 23 : 22 : 10 : 3 : 2.5 : 1.5 : 3 in hind leg. Wings (Plate 1, fig. 4) oval, without scales, with macrotrichia not very abundant, with bare areas along veins distinct and broad. Venation: Costa extending about half length of wing, first radial cell obliterated, second radial cell well formed and as long as first cell, base of M_2 atrophied, fMCu beyond level of second radial cell. Abdomen with tergal and sternal sides black, slightly shiny, membranous areas dark yellow; spermathecae (Plate 1, fig. 23), two, spherical, dark brown; cerci (Plate 1, fig. 18) brown, somewhat discoidal.

Locality.—Saipan Island, Marianna Islands.

Holotype.—Female; Charanka, Saipan Island; October 31, 1937.

Paratopotypes.—Females, October 31, 1937.

This parasitic midge is very closely allied to *P. ariel* Macfie, recorded from Boeroe Island, Moluccas, which differs, however, in the following points: The second radial cell of the wing is almost obliterated, the empodium of the leg consists of short radial lobes, and the tarsal ratio of the hind leg is 3.1.

ATRICHOPOGON FLAVELLUS Kieffer.

This species was recorded from the Philippines in 1921.

Female.—Body about 2.9 millimeters long, almost entirely yellow. Antennal flagellum pale brown. Mesothoracic scutum dull, clothed with brown setae, with humeral spots yellowish white; four scutal vittae yellow, of which median vittae are shorter and paler than lateral; caudoscuteal area whitish yellow; scutellum white. Wings unadorned, with veins yellow. Halteres whitish yellow. Abdominal terga yellowish pale brown.

Head with eyes bare, broadly contiguous above; proboscis shorter than vertical length of head. Antennae each with a distinct sharp terminal stylet which bears two hyaline punctures; basal flagellar segments subspherical, with long sensillae which are almost as long as antennal bristles; antennal ratio about 2.3; proportional lengths of distal seven segments 15 : 15 : 58 :

56 : 64 : 64 : 65. Claws of legs almost straight, each with a small preapical tooth; hind leg with proportional lengths of segments 48 : 46.5 : 33 : 12.5 : 8 : 4 : 5. Wings (Plate 1, fig. 25) with a distinct intercalary fork in cell R_5 , broad bare areas along veins, and a veinlike stripe in cell M_2 . Venation: Costa slightly produced beyond end of Rs and ending about three-fourths of length of wing, second radial cell about four times as long as first (35 : 9). Rs about three and half as long as R_1 (43 : 12), base of M_2 narrowly atrophied, fMCu under middle of first cell and angle of fork very large, about 90° , Cu_1 strongly undulated. Cerci (Plate 2, fig. 40) yellow, discoidal; spermathecae (Plate 1, fig. 41) oval, brown; basal area with many hyaline punctures.

Male.—Body about 2.8 millimeters long; coloration as in female. Head brown, with eyes broadly contiguous. Antennae (Plate 2, fig. 34) with basal segments yellow, distal elongated segments and plumose hairs yellowish brown; proportional lengths of distal seven segments 26 : 23 : 22 : 35 : 120 : 87 : 127; antennal ratio about 1.5. Maxillary palpi 5-segmented (20 : 27 : 45 : 20 : 23); sensory pore of third segment with very short sensillae. Legs with claws long, slender, bifid at tip; empodium very large; proportional lengths of segments 44 : 45 : 29 : 10 : 7 : 5 : 5 in foreleg and 55 : 54 : 39 : 16 : 10 : 5.5 : 5 in hind leg. Wings (Plate 2, fig. 24) without macrotrichia. Venation: Ratio of lengths between first and second radial cells 9 : 32, that between R_1 and Rs 12 : 41, stem of M_{1+2} very short or absent, fMCu under base of second radial cell and not widely differing from female, Cu_1 almost straight. Abdomen brown; hypopygium (Plate 2, fig. 35) brownish yellow; ultimate segment semicircular, without distinct cerci and anal points; coxites slender; styles shorter than coxites, almost straight, dark brown, each with a small preapical tooth; fused ectoparamere V-shaped, with median plate not pointed distally.

Specimens.—Males and females; Lelo, Kusaie Island, Paliker, Kolonia, Ponape Island, and Korrör, Palau Island; November 21, 1937, and January 16 and 29, 1938.

DASYHELEA ESAKII sp. nov.

A yellowish white small species with dark-brown distinct markings. Femora and tibiae of all legs each provided with a middle dark ring, the wing with a black distinct marking on the radial cell.

Female.—Body 1.3 to 1.8 millimeters long; ground color yellowish white, dull. Head yellowish brown. Antenna with scape yellow, pedicel and first flagellar segment white, segments from fourth to ninth yellowish brown, remaining five ultimate segments brown. Thorax with pronotum yellowish white; mesoscutum with three long brown vittæ which are separated from each other by two black lines on anterior area and by two elongated yellowish-white spots on caudoscuteal area; anterior margin of these three vittæ dark brown; median vitta with a dark median line on anterior part, a large dark cloud on middle part, and two small black spots on posterior margin just before scutellum; lateral and anterior margins of scutum yellowish white, with two small black humeral spots on anterior margin and two small brown clouds on either lateral margin; thoracic pleural and sternal sides extensively brown, with several yellowish-white spots; one spot on posterior protergite, a lunate spot on sternepisternum above coxa, a similar spot on notepisternum and epimeron under base of wing, and a similar spot on membranous area under base of haltere. Wing with a very distinct square black spot on second radial cell. Halteres white. Legs mainly white; fore coxæ dark brown on both ends; middle and hind coxæ dark brown; knee joints and distal ends of all tibiæ black; tibiæ and femora of fore and middle legs each with a broad black ring at middle. Abdomen yellowish white, with lateral sides brown; abdominal terga from segments seven to nine each with a pair of dark-brown hemitergal plates; sterna of segments six and seven each with a pair of dark-brown spots; eighth sternum and cerci dark brown.

Eyes pubescent, broadly contiguous above. Maxillary palpi (Plate 2, fig. 39) yellow, 5-segmented (5 : 13 : 22 : 10 : 14); third segment with long scattered sensillæ on middle part. Antennæ (Plate 2, fig. 37) with proportional lengths of distal seven segments 12 : 12.5 : 14 : 16 : 16 : 15 : 21.5; antennal ratio about 0.76. Legs having proportional lengths of segments 20 : 18 : 11 : 3.5 : 2.5 : 2 : 2.5 in foreleg, 27 : 25 : 15 : 4.8 : 3 : 2 : 2.8 in middle leg, and 23 : 21 : 16 : 6 : 4 : 2 : 2.5 in hind leg. Wings (Plate 2, fig. 27) oval, with a square black spot on second radial cell, a faint brown cloud along costal margin beyond radial cells; macrotrichia rather scanty, spread on distal half of wing; bare areas along veins well defined. Venation: Costa ending at middle, first radial cell absent, R_1 and R_s being fused

with each other on basal part, second radial cell square, base of M_2 atrophied, fMCu under base of second radial cell.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Female; Lelo, Kusaie Island; November 21, 1937.

Paratopotypes.—Females; Lelo and Malem, Kusaie Island; November 21 and December 14, 1937.

This species is characteristic, being provided with specific coloration highly differing from other known species of the genus. The wings of *D. esakii* are somewhat similar to those of *D. pacifica* Macfie, recorded from the Marquesas Islands, but the coloration of the thorax and legs is quite different.

DASYHELEA INSULARIS sp. nov.

This species is black and shiny. The wing is provided with a brown spot on second radial cell. The haltere is white. Female unknown.

Male.—Body about 1.1 millimeters long. Head dark brown, with eyes hairy and contiguous above. Antennæ (Plate 2, fig. 33) dark brown; antennal ratio about 0.9; relative lengths of distal seven segments 12 : 12.5 : 12.5 : 23 : 30 : 31 : 24. Mouth parts also dark brown; maxillary palpi (Plate 2, fig. 32) 5-segmented (5 : 8 : 16 : 9 : 10), with scattered sensillæ on third segment. Thorax shiny, black; scutellum white; pleural membranes gray. Legs dark brown, with distal four tarsal segments somewhat paler; proportional lengths of segments of hind leg 17 : 18 : 10 : 5 : 4 : 2.5 : 2.5. Wings (Plate 2, fig. 26) with broad bare areas along veins. Venation: Costa ending before middle of wing, first radial cell absent, second radial cell obliterated, Rs squarely ending, fMCu beyond end of costa. Abdomen gray; terga and hypopygium brownish black; hypopygium (Plate 2, fig. 36) with points slender and each with a small terminal seta; coxites broad, short; style straight, non-pubescent on distal one-third; fused ectoparamere broad at middle, with an apical small spinelike projection.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Male; Malem, Kusaie Island; December 14, 1937.

This species is closely allied to *D. tersa* Johannsen, reported from West Java, which, however, distinctly differs in the following points: The eyes are not contiguous above but separated from one another by a fine line, and the proportional lengths of the distal six antennal segments are 16 : 38 : 30 : 25 : 25 : 46.

CULICOIDES KUSAIENSIS sp. nov.

This species is quite characteristic in possession of the unadorned wings which are provided with erect sparse macrotrichia, and reduction of the male antennæ which are not provided with plumose hairs and are incompletely segmented with less than 14 segments. The biting habits of the fly are unknown.

Female.—Body about 1.4 millimeters long, brown in ground color; wings uniformly fuscous, with veins brown, without colored markings.

Head brown, with eyes bare, very narrowly separated above; mouth parts brown, proboscis about half as long as head; maxillary palpi 5-segmented (4 : 10 : 15 : 6 : 9), with sensory pore of *obsoletus*-subtype. Antennæ (Plate 2, fig. 38) brown, 14-segmented, with antennal ratio 1.3 to 1.4; proportional lengths of distal eight segments 10 : 10 : 10 : 20 : 21 : 24 : 25 : 30 : 5. Thoracic tergum almost uniformly brown; mesoscutum with a pair of white humeral pits, a pair of pale-brown stripes on caudoscuteal area, and a pair of pale obscure narrow stripes along pseudosutural foveæ; scutellum pale brown; thoracic pleural sclerites pale brown; other thoracic sclerites brown. Legs uniformly brown; fourth tarsal segments cylindrical; proportional lengths of segments of hind legs about 20 : 20 : 9 : 4.5 : 3.8 : 2 : 2. Wings (Plate 1, fig. 29) broad, oval, uniformly fuscous, without colored markings; macrotrichia short, erect, sparsely scattered almost all over surface of wing. Venation: first radial cell hardly as long as second, M_{1+2} very short, base of M_2 atrophied, fMCu far beyond f M_{1+2} . Halteres brown. Abdomen brown; sternal side pale brown; sternal plate subdivided at middle.

Male.—Body about 1.2 millimeters long. Antennæ without plumose hairs, 13-segmented at most, in extreme cases only 9-segmented, segments six to ten more or less fused; antennal ratio varying from 1.3 to 1.6; proportional lengths of distal three segments 37.3 : 31.7 : 35.7. Legs with relative lengths of segments 15 : 15 : 7.5 : 3.5 : 2 : 1.8 : 2 in foreleg, 19 : 19 : 9 : 3.4 : 2.5 : 1.7 : 2 in middle leg, and 18 : 18 : 7.5 : 4.5 : 2.5 : 2 : 2.5 in hind leg. Wings (Plate 2, fig. 28) with macrotrichia erect, very sparse; first radial cell very narrow, linear; M_{1+2} longer than in female; fMCu under f M_{1+2} . Sternal plate of each abdominal

segment narrowed at middle; hypopygium (Plate 2, fig. 30) brown, with anal points very short, blunt; fused paramere slender, bifurcated at end; gonapophyses strongly angulated, sharply pointed distally; styles slender, arcuated, as long as coxites, pubescent on basal half, pointed at end. Other structures and coloration closely as in female.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Male; Malem, Kusaie Island; December 14, 1937.

Allotopotype.—Female; December 14, 1937.

Paratopotypes.—Females; December 14, 1937.

This species is highly specific in the structure of the wing, and the male antennæ and differs extremely from the other known biting midges, as mentioned above.

CULICOIDES ARDENTISSIMUS sp. nov.

This species was taken at Malem together with *C. kusaiensis*. The coloration and structures of the body are very closely related to those of the preceding species. The male and the blood-sucking habits of the female are unknown.

Female.—Body about 1.7 millimeters long; head, thorax, and legs all reddish brown; wings without colored markings; halteres brown.

Head with eyes bare and very narrowly separated above; mouth parts reddish brown; proboscis slightly shorter than vertical length of head; maxillary palpi (Plate 2, fig. 31) slender, 5-segmented (8 : 23 : 23 : 9 : 12), each with a large sensory pore of *obsoletus* subtype consisting of short sensillæ. Antennæ with antennal ratio about 1.44; proportional lengths of distal seven segments about 12 : 11.5 : 24 : 25 : 28 : 29 : 34. Thoracic tergum reddish brown, shiny; mesoscutum with markings closely similar to those of *C. kusaiensis*. Legs with fourth tarsal segments cylindrical; claws each with a long basal seta; relative lengths of segments 21 : 21 : 10 : 4 : 2.5 : 2 : 2.8 in foreleg, 26 : 26 : 13 : 4 : 3 : 2.1 : 2.8 in middle leg, and 24 : 24 : 12 : 5.1 : 3.2 : 2.8 : 3 in hind leg. Wings with macrotrichia thickly spread over surface; two rows of macrotrichia extending basally between veins M and Cu₁; veins brown. Venation as in preceding species. Abdomen yellowish white; tergal and sternal plates reddish brown; sternal plates of first two segments atrophied; those of remaining segments each subdivided into one pair of small plates.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Female; Malem, Kusaie Islands; December 14, 1937.

This species is closely allied to *C. kusaensis*, as stated already, but easily distinguished from the latter by the following characters: The general coloration is darker, the body is larger, the wings are provided with thicker macrotrichia, the maxillary palpi are longer and slenderer, and the proboscis is far longer.

CULICOIDES ESAKII sp. nov.

A very troublesome biting midge, severely attacking men, and very abundant at Ponape, Caroline Islands. Male unknown.

Female.—Body 0.78 to 1.1 millimeters long, yellow in ground color. Thorax shiny; anterior half of scutum with dark-brown markings; scutellum yellow. Wings 0.7 to 0.9 millimeter long, with large subconfluent clear spots, macrotrichia sparse on distal one-third. Halteres yellowish white.

Head brown on vertex, yellowish brown in frontal aspect; eyes separated from one another, as wide as diameter of an ommatidium. Antennæ (Plate 3, fig. 57) yellowish brown or brown; antennal ratio 1 to 1.2; proportional lengths of distal seven segments 9 : 8.5 : 8.5 : 12.5 : 13.5 : 15.5 : 21. Mouth parts pale brown; proboscis about half as long as head (38 : 70); maxillary palpi (Plate 3, fig. 53) 5-segmented (5 : 12 : 12 : 7 : 7); third segment with a sensory pore of *obsoletus* subtype. Thorax yellow, shiny; pronotum dark brown; mesoscutum dark brown on anterior half and with two pairs of circular lateral and a pair of large oval medial yellow spots on dark anterior area, yellow on posterior half and with a pair of dark-brown narrow lateral stripes and a brown median cloud on the yellow posterior area; scutellum yellow with a small brown median cloud; post-scutellum black; pleural and sternal sides extensively yellow, with sternepisternum and notepisternum dark brown. Legs with coxæ, trochanters, femora, tibiæ, and basitarsi mainly brown, broadly yellowish white before and beyond knee joints; bases of femora narrowly yellowish brown; hind tibiæ very broadly yellowish white apically; distal four tarsal segments all pale brown; fourth tarsal segments cylindrical; claws simple; empodium vestigial. Proportional lengths of segments, except coxæ and trochanters, 76 : 71 : 36 : 13 : 10 : 7 : 10 in foreleg, 97 : 93 : 50 : 15 : 11 : 9 : 12 in middle leg, and 88 : 83 : 37 : 17 :

11 : 8 : 12 in hind leg. Wings (Plate 3, fig. 44) with adornment closely similar to that in *C. sigaensis* Tokunaga: first costal spot covering r-m and basal half of first radial cell, second spot covering distal one-third of second radial cell, second and third dark costal bands subequal in breadth, pale stripes along vein M_1 ; macrotrichia sparse, on distal one-third of wing, sometimes absent in cell M_1 . Venation: first radial cell half as long as second, M_1 and M_2 slightly undulated, stem of Cu_1 also undulated, base of M_2 obsolete, fMCu slightly before or just under f M_{1+2} . Abdomen yellowish white, uniformly or broadly brown on lateral sides. Spermatheca (Plate 3, fig. 55) only one, yellowish brown, short oval.

Locality.—Ponape Island, Caroline Islands.

Holotype.—Female; Nampir-Sankakuyama, Ponape; January 3, 1938.

Paratopotypes.—Females; January 3, 1938.

This species is very closely allied to *C. orientalis* Macfie, from which it notably differs in possession of yellow spots on the mesoscutum. *C. gymnopterus* Edwards is also related to the present species, differing from it in the following characters of the wings: Macrotrichia restricted to less than a dozen at extreme tip of wing, second radial cell entirely pale, vein between R_1 and R_s absent. Japanese related species may be *C. maculatus* Shiraki, *C. sigaensis* Tokunaga, and *C. kyotoensis* Tokunaga, all very closely similar to the present midge in the coloration of the wings; the present midge is, however, highly characteristic in the following points of the wing venation: stem of Cu_1 distinctly undulated, fMCu located before or under f M_{1+2} . Besides the difference of the wing venation, in *C. maculatus* the sexual organ is provided with two spermathecae and the basal flagellar segments of the antennae are oval and elongated; in *C. sigaensis* the thoracic ground color is dark or reddish brown and the basal flagellar segments of the antennae are also elongated and oval; in *C. kyotoensis* the legs are uniformly pale yellow, the thoracic ground color is brown, the scutum is provided with four vittae, the scutellum is brown, and the basal flagellar segments of the antennae are also elongated.

SERROMYIA ESAKII sp. nov.

A yellow species, somewhat related to *S. nudipennis* Kieffer, reported from Gallia. Male unknown.

Female.—Body 2.2 to 2.3 millimeters long, yellow in ground color. Head yellowish brown, with appendages brownish yellow. Thorax yellow, not shiny, setæ black; mesoscutum with three vittæ orange yellow; pleural and sternal sclerites yellow, with brownish clouds. Legs with coxæ and trochanters brownish yellow; other segments mainly yellowish white; fore and middle tibiæ with distal parts brown; hind legs with knee joints black; hind tibiæ broadly dark brown at base. Halteres white; knobs dark on marginal area. Wings without colored markings; veins hyaline and colorless. Abdomen white.

Eyes bare, narrowly separated above. Antenna (Plate 3, fig. 54) with a small preapical seta on base of blunt stylet; relative lengths of distal seven segments 14 : 14 : 24 : 27 : 31 : 31 : 38; antennal ratio 1.2 to 1.3. Thorax without scutal spine on anterior margin. Fore and middle legs with fourth tarsal segments flattened, obliquely truncated; hind leg with femur thickened, with many (20) strong spinelike bristles on ventral side besides ordinary strong setæ; hind tibia strongly curved basally; first tarsal segments of all legs each with a basal and an apical spurlike bristle; those of forelegs each with three similar bristles on middle part; second and third tarsal segments of fore and middle legs each with one or two apical bristles; other tarsal segments without spurlike bristles; tarsal claws of fore and middle legs small, symmetrical; hind tarsal claws very unequal, relative lengths of paired claws 17 : 85; longer claw slender, very long, longer than fifth tarsal segment (85 : 50), with a small basal tooth; shorter claw simple; proportional lengths of segments of foreleg 30 : 28 : 15 : 6.5 : 4 : 2.5 : 4, those of middle leg 36 : 35 : 19 : 8 : 5 : 2.5 : 4, those of hind leg 49 : 38 : 20 : 11 : 8 : 6 : 8. Wing (Plate 3, fig. 45) with macrotrichia restricted to less than fourteen at margin of extreme tip. Venation: Costa ending at three-fourths of wing, relative lengths of first and second radial cells 11 : 19, of R_1 and R_s 14 : 30, r-m almost vertical and very short, M_{1+2} short, about thrice of r-m, fMCu under r-m.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Female; Malem, Kusaie Island; December 14, 1937.

Paratopotype.—Female; December 14, 1937.

This species is related to *S. nudipennis* Kieffer, but the latter is reddish brown or brown in ground color, the abdomen of the

female is brown, and the longer tarsal claw of the hind leg is only about thrice as long as the shorter one and about equal to segment five of hind leg.

CHIRONOMIDÆ

CHIRONOMUS DORSALIS Meigen.

A cosmopolitan species, widely distributed in the northern hemisphere. The specimens examined were collected from Truk and Kusaie Islands.

Male and female.—Body 4.5 to 5 millimeters long, yellowish white in alcoholic specimens. Head pale brown, with frontal tubercles pubescent. Male antenna with scape yellow, flagellum brown; antennal ratio 2.6 to 2.7. Female antenna 6-segmented (5 : 10 : 7.8 : 8 : 7.2 : 10.5), with a preapical seta. Mouth parts brown, with palpi 5-segmented (3 : 3 : 7.5 : 9.5 : 21 in male). Thoracic sclerites yellow; mesoscutum with three vittæ orange; postscutellum also orange. Legs yellow, with last tarsal segments brown; distal ends of all tarsal segments dark brown; foreleg ratio about 1.85 in male and 1.9 in female. Wings with veins yellow; r-m and base of Rs dark; anal margin very slightly constricted at end of Cu₁; in male fMCu slightly beyond r-m, R₂₊₃ ending closely near by R₁. Abdomen brownish yellow, terga from second to fourth each with a dark median band. Male hypopygium as in Plate 3, fig. 61.

Specimens.—Males and females; Toloas-Erin, Truk Island and Lelo, Kusaie Island; November 14 and December 4, 1937.

CHIRONOMUS LONGILOBUS Kieffer.

This species was first described from Formosa by J. Kieffer. The specimens examined were collected at Toloas-Erin, Truk Island.

Male.—Body length 4 to 4.2 millimeters; ground color yellowish brown. Antenna with scape and pedicel yellow, flagellum brown, plumose hairs yellowish brown. Thoracic mesoscutum shining, with two median vittæ pale brown, two lateral vittæ brown; postscutellum brown. Legs pale brownish yellow; foreleg with knee joint broadly dark, distal end of tibia broadly dark, tarsus pale brown; middle and hind legs with knee joints narrowly dark, tibial end black only on tibial combs, tarsi yellowish pale brown. Wings with veins all brown even on crossvein. Halteres yellow. Abdomen yellowish brown; last two segments and hypopygium dark.

Head with frontal tubercles minute, spherical, bare. Maxillary palpi 5-segmented (2 : 2.7 : 6 : 9 : 12.5). Antennal ratio 1.74 to 1.96. Legs without beards; tibial combs each with a spur; leg ratio of foreleg 1.64 to 1.67. Wing with vein R_{2+3} ending before middle between ends of R_1 and R_{4+5} , fMCu beyond r-m. Hypopygium (Plate 3, fig. 60) with anal point basally setigerous, squarely truncated apically and thickened longitudinally on dorsal side; style short, somewhat oval, with a strong black spine at tip; dorsal appendage bare; ventral appendage slender, long, extending caudad as long as style.

Female.—Body 3 to 4 millimeters long; ground color pale brown. Antennæ yellowish brown; last segment brown. Four mesoscutal vittæ dark brown; postscutellum dark brown. Abdomen pale brown; last segment with sternum brown. Maxillary palpi 5-segmented (3 : 4.5 : 6.5 : 10 : 15.5). Antennæ 6-segmented (4 : 9 : 6 : 6 : 5.2 : 9.5), each with a preapical seta; segments three to five flask-shaped, each with a prominent neck region. Foreleg ratio 1.7 to 1.71. Wings 2.5 millimeters long; vein R_{2+3} ending one-fourth between ends of R_1 and R_{4+5} .

Specimens.—Males and females; Toloas-Erin, Truk Island; November 14, 1937.

CHIRONOMUS ESAKII sp. nov.

A pale brownish-yellow species.

Male.—Body about 4 millimeters long; thorax with four brown vittæ.

Head with frontal tubercles small; mouth parts brown. Antenna with flagellum brown, 12-segmented; antennal ratio 1.55 to 1.6. Thorax pale brownish yellow, with four scutal vittæ brown; postscutellum brown, with a pale median stripe; epimeral sclerites brownish yellow. Legs yellow; distal ends of tarsal segments and ultimate segments brown or dark brown; leg ratio of foreleg 1.6 to 1.7. Wings (Plate 3, fig. 46) with veins yellow, R_{2+3} extending closely along R_1 , fMCu just beyond r-m, r-m without dark marking. Halteres yellow. Abdomen pale brownish yellow, ultimate two terga and hypopygium brown; ultimate tergum (Plate 3, fig. 51) highly setigerous on median area and sparsely setigerous on lateral sides, with anal point very prominent, forming a high ridge; coxite short; style very thickened, short, with a dorsal ridge, highly setigerous with very strong bristles on mesal area; dorsal appendage bare, fingerlike; ventral appendage with branched bristles.

Female.—Antenna 6-segmented (18:48:33:37:35:60), without apical setæ. Spermathecae yellow, spherical; other structures and coloration almost similar to those of male.

Locality.—Saipan Island, Marianna Islands.

Holotype.—Male; Charanka, Saipan Island; November 1, 1937.

Allotopotype.—Female; November 1, 1937.

Paratopotypes.—Male and female; November 1, 1937.

In coloration this species is somewhat related to *C. quadratus* Johannsen, recorded from Java, and in the structure of the male hypopygium to *C. grandilobus* Kieffer, recorded from Formosa.

PENTAPEDILUM ESAKII sp. nov.

A yellowish-brown species provided with four dark-brown vittæ on scutum.

Female.—Body 2 to 2.2 millimeters long. Mesoscutum not shiny, with four dark-brown vittæ; caudoscuteal area brown. Legs with femoral end broadly faintly brown; tibiae and tarsi pale brown; hind coxæ pale brown; other segments brownish yellow. Halteres white. Abdominal terga pale brown; caudal segments brown.

Head with eyes bare. Maxillary palpi 5-segmented (3:2.3:8:10:14.5). Antennæ 6-segmented (3:6.8:4.2:4:4:7), each with two preapical setæ; intermediate flagellar segments each with a short neck region. Pronotum divided at middle, very narrow. Legs with claws, pulvilli, and empodia normal; foreleg with third tarsal segment barely longer than fourth (25:23); tibial combs one with a long and the other with a vestigial spur; foreleg ratio about 1.34. Wings (Plate 3, fig. 48) hairy all over, with bare areas along R_{4+5} , M_{3+4} , and Cu_1 ; costa not produced beyond end of R_{4+5} ; R_{2+3} extending along R_1 ; fMCu beyond r-m. Abdomen short, swollen, oval; cerci somewhat ear-shaped, with blunt ventral projection.

Locality.—Kusaie Island, Caroline Islands.

Holotype.—Female; Malem, Kusaie Island; December 14, 1937.

Paratopotypes.—Females; December 14, 1937.

This species is related to *P. nodosum* Johannsen, recorded from Java, which, however, is provided with two reddish spots on either pleural sides of the thorax, has the longer ultimate segment of the antenna over twice the fifth, the elongated intermediate flagellar segments each of which bears a long neck region, the larger foreleg ratio about 1.7, and the long fourth tarsal segments of the foreleg far longer than the third (17:11).

PENTAPEDILUM TRUKENSIS sp. nov.

This species is provided with bicolorous scutal vittæ and cuneiform wings.

Male.—Body about 1.2 millimeters long. Head pale brown, eyes bare. Antennæ including plumose hairs brown. Thorax pale brown, mesoscutum with lateral vittæ dark, median vitta yellowish brown; postscutellum dark; pleural side with a dark stripe extending from neck to abdominal base. Legs yellowish white; femora very broadly dark brown on distal two-thirds; tibiæ also very broadly dark brown on basal three-fourths. Wings with veins brown. Halteres brownish white. Abdomen pale brown, posterior terga brown.

Antennæ 14-segmented, each with three apical setæ; ultimate segment equal in length to preceding eight segments taken together; antennal ratio about 0.7. Legs with pulvilli small; tibial combs one with a long and the other with a very short spur; fore tarsi broken off. Wings (Plate 3, fig. 47) cuneiform, with macrotrichia sparse, scattered almost all over; squama with two marginal setæ; venation: R_1 and R_{4+5} very widely separated at end, R_{2+3} extending along R_1 , r-m very oblique, fMCu far beyond r-m. Hypopygium (Plate 3, fig. 59) with anal point very slender, clavate at end; styles slender, very long, twice or more longer than coxites; dorsal appendage very large, spherical, pubescent, with an apical hookletlike projection; ventral appendage clavate and curved dorsad at end, with a long preapical and many strong apical setæ on clavate end.

Locality.—Truk Island, Caroline Islands.

Holotype.—Male; Toloas-Erin, Truk Island; November 14, 1937.

This species is highly different from the known species of the genus, being provided with characteristic structures of the antennæ (small value of antennal ratio), the wing (cuneiform outline and widely separated R_1 and R_{4+5}), and the hypopygium (swollen dorsal appendages). The dark stripe of the pleural side of the thorax extending from the neck to the abdominal base is another distinct specific character to distinguish *P. trukensis* from the other *Pentapedilum* species.

TANYTARSUS HALOPHILÆ Edwards.

This marine species was recorded from a *Halophila* lagoon protected by a coral reef around the island of Samoa. The specimens examined at this time were mainly collected from Kusaie Island, and some of them were taken at light on the decks of a steamer lying about 300 meters from the island.

Male and female.—Body 1.5 to 2 millimeters long; ground color yellowish white. Male antenna with scape and pedicel white, flagellum pale brown; ultimate segment shorter than preceding three (40 : 50) but longer than preceding two segments taken together (40 : 35); antennal ratio 0.21 to 0.23. Female antenna 5-segmented (13.5 : 25.5 : 20 : 20 : 41.5). Maxillary palpi 5-segmented (5 : 10 : 42 : 47 : 74 in male and 7 : 8 : 33 : 38 : 60 in female). Mesothoracic scutum with a yellow median and two pale brownish-yellow lateral vittæ; postscutellum with two yellowish pale-brown clouds. Legs entirely yellow; leg ratio of foreleg of male about 1.76, that of female 1.7 to 1.8. Wings (Plate 3, fig. 52) with macrotrichia comparatively thick, fMCu beyond r-m. Male hypopygium (Plate 3, fig. 58) with anal point broad, flattened, setigerous; ventral appendage large, with many strong bristles; dorsal appendage elongated, with several setæ, its accessory lobe fingerlike, without setæ; ventro-proximal appendage relatively long, with tuft of simple setæ on distal part. Female cerci (Plate 3, fig. 64) elongated, slender, hardly thrice its width.

Specimens.—Males and female; Lelo and Malem, Kusaie Island; Caroline Islands; November 21 and December 14, 1937.

TANYTARSUS ESAKII sp. nov.

Very closely allied to the marine midges *T. halophilæ* Edwards and *T. maritimus* Edwards, recorded from the Samoa Islands and apparently marine in habitat, the females being provided with elongated cerci, which have been known only in marine species of the genus.

Male.—Body length about 2 millimeters; ground color almost entirely yellowish white; thorax with four brownish vittæ.

Head with eyes bare; no frontal tubercles. Antennæ 14-segmented, with plumose hairs rather scanty and pale brown; scape pale brown on basal half; ultimate segment shorter than preceding five, but longer than four segments taken together; antennal ratio about 0.4. Thoracic mesoscutum with four vittæ separated and brown or pale brown; median vittæ dark brown or brown on anterior half; postscutellum brown or pale brown. Legs yellow; leg ratio of foreleg 1.75 (1.6 to 1.9). Wings (Plate 3, fig. 49) with macrotrichia sparse; fMCu just beyond r-m, the latter very short. Hypopygium (Plate 3, fig. 62) without anal point; ultimate tergum with several setæ on caudomesal area; styles very broad; dorsal appendage with only four setæ, accessory lobe very small, slightly clavate, with two apical setæ;

ventral appendage comparatively slender, with setæ relatively sparse; ventroproximal appendage small, crowned with a tuft of simple setæ.

Female.—Body 1.4 to 1.5 millimeters long. Eyes reniform, widely separated above. Antennæ yellow, 5-segmented (10 : 26 : 16 : 17 : 32); ultimate segment pale brown on distal half or more, with two apical setæ; segments three and four fusiform, each with a short neck region. Maxillary palpi 5-segmented (8 : 10 : 30 : 35 : 60). Middle and hind tibiæ each with two combs which are widely separated and each provided with a spur. Wings (Plate 3, fig. 50) broader and more hairy than in male; bare areas along veins obscure. Ultimate sternum elongated, setigerous on caudal margin, with a small shallow caudal incision; cerci (Plate 3, fig. 63) elongated, pointed apically, about two and half times as long as wide; spermathecae (Plate 3, fig. 56) yellow, spherical, with very short neck region.

Locality.—Ponape Island, Caroline Islands.

Holotype.—Male; Kolonia, Ponape Island; January 17, 1938.

Allotopotype.—Female; January 17, 1938.

Paratopotypes.—Males and females; January 17, 1938.

This species is very closely allied to the Samoan marine species *T. maritimus* Edwards and *T. halophilæ* Edwards. In *T. maritimus*, however, the wing is very sparsely clothed with macrotrichia: in the male wing the macrotrichia are a few around the tip and a row in cell R_5 , in the female wing the macrotrichia are absent in the anal area, and the ultimate segment of the male antenna is shorter than the preceding three segments taken together. In *T. halophilæ* the third and fourth antennal segments of the female have no neck region and the hypopygium of the male is highly different in the structure of the ultimate tergum from the present species.

TANYTARSUS sp. No. 1.

This species is about 2 millimeters long and yellowish white in ground color. The mesothoracic scutum bears three pale-yellow vittæ.

Female.—Head without frontal tubercles; eyes bare, reniform, widely separated above. Maxillary palpus 5-segmented (3 : 2 : 6 : 8 : 11). Antenna 5-segmented (15 : 34 : 22 : 22 : 40); terminal segment with a preapical seta; segments three and four with neck region very short. Scutal vittæ pale yellow, median vitta paler than lateral; postscutellum pale yellow, with a median white stripe. Leg ratio of foreleg about 1.4; pulvilli

as long as claws. Wings hairy all over surface; costa not produced beyond end of R_{4+5} ; fMCu slightly beyond r-m. Cerci very short.

Specimen.—Female; Malem, Kusaie Island; December 14, 1937.

This species seems to be identical with an undetermined *Tanytarsus* reported by Prof. O. A. Johannsen in 1932 from central Java.

TANYTARSUS sp. No. 2.

This undetermined species is very closely similar to *Tanytarsus* sp. No. 1. The body is almost entirely yellowish white, 1.8 to 2 millimeters long.

Female.—Head without frontal tubercles; eyes bare, reniform. Antenna 5-segmented (14 : 33 : 21 : 21 : 38), with an apical seta; third and fourth segments with neck region obscure. Mesothoracic scutum with lateral vittæ yellow, median vittæ dark brown; postscutellum dark brown, with a yellowish white median stripe. Fore tarsi broken off; pulvilli as in *Tanytarsus* sp. No. 1. Wings with macrotrichia numerous, all over surface, but sparser than in preceding species.

Specimens.—Females; Kolonia, Ponape Island; January 17, 1938.

BIOLOGICAL NOTES

By TEISO ESAKI

LASIOHELEA PECTINUNGUIS de Meijere.

Many females; Lelo, Kusaie Island, November 30, 1937.

This species was found on a sphingid moth, *Chromis erotus eras* Boisduval, which I captured at the edge of a window of my lodging house. The moth flew into the room the preceding evening, attracted by light, and was at rest when I discovered it, and I noticed at once that it was infested by a number of small midges. When I put the moth carefully into a killing bottle, nearly one half of the midges escaped from the body of the host before they were killed. No less than 30 specimens were found in all, and they were crowded on the forewings near the base and more sparsely on the dorsal surface of the thorax and of the basal part of the abdomen of the host. They crawled into the scales of the host, thus concealing the anterior parts of their body, and were undoubtedly sucking blood from the host.

PTEROBOSCA ADHESIPES Macfie.

Females; Kolonia-Nat, Ponape Island, November 19, 1937; Mwot-Utwe and Fwincol, Kusaie Island, December 8 and 9, 1937.

These minute midges were found exclusively on the wings of dragon flies. They were generally clinging to the veins near the base of the wings, and they escaped from the host when disturbed. In some specimens the abdomina were strongly swollen with blood from the host. The number of the parasites on a single host is rather small, ranging from one to three. The following dragon flies were observed as hosts of this midge: ¹ From Ponape Island: *Tramea limbata* Desjardines, *Agrionoptera insignis similis* Selys, *Tholymus tillarga* Fabricius, *Hemicordulia* sp. No. 1; from Kusaie Island: *Tholymis tillarga* Fabricius, *Diplacodes bipunctata* Brauer, *Hemicordulia* sp. No. 2.

PTEROBOSCA ESAKII Tokunaga.

Females: Charanka, Saipan Island, October 31, 1937.

This midge was also found on the wings of dragon flies. The dragon flies occurring along the Charanka Lake, Saipan, were strongly infested by it, nearly every host bearing one or two midges, the maximum number of the parasites on a single host being 7. However, in other places in Saipan the midges were rarely observed.

The following hosts were ascertained: *Tramea limbata* Desjardines, *Pantala flavescens* Fabricius, *Tholymis tillarga* Fabricius, *Diplacodes bipunctata* Brauer.

CULICOIDES ESAKII Tokunaga.

Many females; Nampir, Ponape Island.

This very minute midge is well known among the natives and residents in Ponape, the natives calling it *amuinucl* or *em en uál*.² It is abundant and troublesome throughout forests in the mountainous regions in Ponape, attacking men in daytime. The annoyance caused by this midge is however much less severe than that of *Culicoides peliliouensis* Tokunaga of the Palau Islands, probably due to the more minute size of the midge, and no remarkable inflammation occurs after the infestation. The larval life of this midge is undoubtedly carried out in the streams.

TANYTARSUS HALOPHILÆ Edwards.

Lelo, Kusaie Island, November 21, 1937. Malem, Kusaie Island, December 14, 1937.

¹ Kindly identified by Mr. S. Asahina.

² Gnats of the forest.

This minute midge was captured at light in the evening. In the former locality this species was captured with many other Diptera on board in the harbors of Kusaie. In Malem I observed a tremendous number of these midges swarming into the room.

TANYTARSUS ESAKII Tokunaga.

TANYTARSUS sp. No. 2.

Kolonia, Ponape Island, January 17, 1938.

These species were captured also at light in the evening. The former midge was found in a large swarm, as in the case of *Tanytarsus halophilæ* Edwards, observed at Malem, Kusaie.

FORCIPOMYIA ESAKIANA Tokunaga.

CHIRONOMUS DORSALIS Meigen.

CHIRONOMUS LONGILOBUS Kieffer.

PENTAPEDILUM TRUKENSIS Tokunaga.

Toloas Erin, Truk Island, November 14, 1937.

These species were collected by sweeping among the weeds.

CHIRONOMUS ESAKII Tokunaga.

Charanka, Saipan Island, November 1, 1937.

This species was also collected by sweeping among the weeds.

FORCIPOMYIA ESAKIANA Tokunaga.

LASIOHELEA CAROLINENSIS Tokunaga.

DASYHELEA ESAKII Tokunaga.

DASYHELEA INSULARIS Tokunaga.

ATRICHOPOGON FLAVELLUS Kieffer.

CULICOIDES KUSAIENSIS Tokunaga.

CULICOIDES ARDENTISSIMUS Tokunaga.

SERROMYIA ESAKII Tokunaga.

PENTAPEDILUM ESAKII Tokunaga.

TANYTARSUS HALOPHILÆ Edwards.

TANYTARSUS sp. No. 1.

Kusaie Island.

Of these several species the specimens from Lelo, November 21, 1937, were captured together with a great many crane flies of marine habitat, *Limonia* (*Idioglochina*) *kotoshoensis* Alexander, *Limonia* (*Dicranomyia*) *pectinunguis* Tokunaga, and *Limonia* (*Dicranomyia*) *pontophila* Tokunaga, on board at light in the harbor of Kusaie, about 300 meters off the islet Lelo.

Those from Malem, December 14, 1937, were also attracted by light in the evening, together with a large swarm of a minute chironomid, *Tanytarsus halophilæ* Edwards.

ILLUSTRATIONS

PLATE 1

- FIG. 1. *Forcipomyia esakiana* sp. nov., male wing.
 2. *Forcipomyia esakiana* sp. nov., female wing.
 3. *Pterobosca adhesipes* Macfie, female wing.
 4. *Pterobosca esakii* sp. nov., female wing.
 5. *Lasiohelea pectinunguis* de Meijere, female wing.
 6. *Lasiohelea carolinensis* sp. nov., female wing.
 7. *Lasiohelea pectinunguis* de Meijere, female antenna.
 8. *Pterobosca adhesipes* Macfie, female maxillary palpus.
 9. *Pterobosca esakii* sp. nov., female maxillary palpus.
 10. *Pterobosca adhesipes* Macfie, female antenna.
 11. *Pterobosca esakii* sp. nov., female antenna.
 12. *Forcipomyia esakiana* sp. nov., distal segments of male antenna.
 13. *Lasiohelea pectinunguis* de Meijere, fifth tarsal segment and claws of female leg.
 14. *Pterobosca esakii* sp. nov., claw and empodium of female leg.
 15. *Forcipomyia esakiana* sp. nov., male hypopygium.
 16. *Lasiohelea pectinunguis* de Meijere, female maxillary palpus.
 17. *Pterobosca adhesipes* Macfie, female cercus.
 18. *Pterobosca esakii* sp. nov., female cercus.
 19. *Lasiohelea carolinensis* sp. nov., spermatheca.
 20. *Pterobosca adhesipes* Macfie, spermatheca.
 21. *Lasiohelea pectinunguis* de Meijere, female cercus.
 22. *Lasiohelea pectinunguis* de Meijere, spermatheca.
 23. *Pterobosca esakii* sp. nov., spermatheca.

PLATE 2

- FIG. 24. *Atrichopogon flavellus* Kieffer, male wing.
 25. *Atrichopogon flavellus* Kieffer, female wing.
 26. *Dasyhelea insularis* sp. nov., male wing.
 27. *Dasyhelea esakii* sp. nov., female wing.
 28. *Culicoides kusaiensis* sp. nov., male wing.
 29. *Culicoides kusaiensis* sp. nov., female wing.
 30. *Culicoides kusaiensis* sp. nov., male hypopygium.
 31. *Culicoides ardentissimus* sp. nov., female maxillary palpus.
 32. *Dasyhelea insularis* sp. nov., male maxillary palpus.
 33. *Dasyhelea insularis* sp. nov., distal segments of male antenna.
 34. *Atrichopogon flavellus* Kieffer, male antennal segments from ninth to twelfth.
 35. *Atrichopogon flavellus* Kieffer, male hypopygium.
 36. *Dasyhelea insularis* sp. nov., male hypopygium.
 37. *Dasyhelea esakii* sp. nov., distal segments of female antenna.

- FIG. 38. *Culicoides kusaiensis* sp. nov., female antenna.
 39. *Dasyhelea esakii* sp. nov., female maxillary palpus.
 40. *Atrichopogon flavellus* Kieffer, female cercus.
 41. *Atrichopogon flavellus* Kieffer, spermatheca.
 42. *Lasiohelea carolinensis* sp. nov., female maxillary palpus.
 43. *Lasiohelea carolinensis* sp. nov., female antenna.

PLATE 3

- FIG. 44. *Culicoides esakii* sp. nov., female wing.
 45. *Serromyia esakii* sp. nov., female wing.
 46. *Chironomus esakii* sp. nov., male wing.
 47. *Pentapedilum trukensis* sp. nov., male wing.
 48. *Pentapedilum esakii* sp. nov., female wing.
 49. *Tanytarsus esakii* sp. nov., male wing.
 50. *Tanytarsus esakii* sp. nov., female wing.
 51. *Chironomus esakii* sp. nov., male hypopygium.
 52. *Tanytarsus halophilæ* Edwards, male wing.
 53. *Culicoides esakii* sp. nov., female maxillary palpus.
 54. *Serromyia esakii* sp. nov., female antenna.
 55. *Culicoides esakii* sp. nov., spermatheca.
 56. *Tanytarsus esakii* sp. nov., spermatheca.
 57. *Culicoides esakii* sp. nov., female antenna.
 58. *Tanytarsus halophilæ* Edwards, male hypopygium.
 59. *Pentapedilum trukensis* sp. nov., male hypopygium.
 60. *Chironomus longilobus* Kieffer, male hypopygium.
 61. *Chironomus det~~s~~alis* Meigen, male hypopygium.
 62. *Tanytarsus esakii* sp. nov., male hypopygium.
 63. *Tanytarsus esakii* sp. nov., female cercus.
 64. *Tanytarsus halophilæ* Edwards, female cercus.

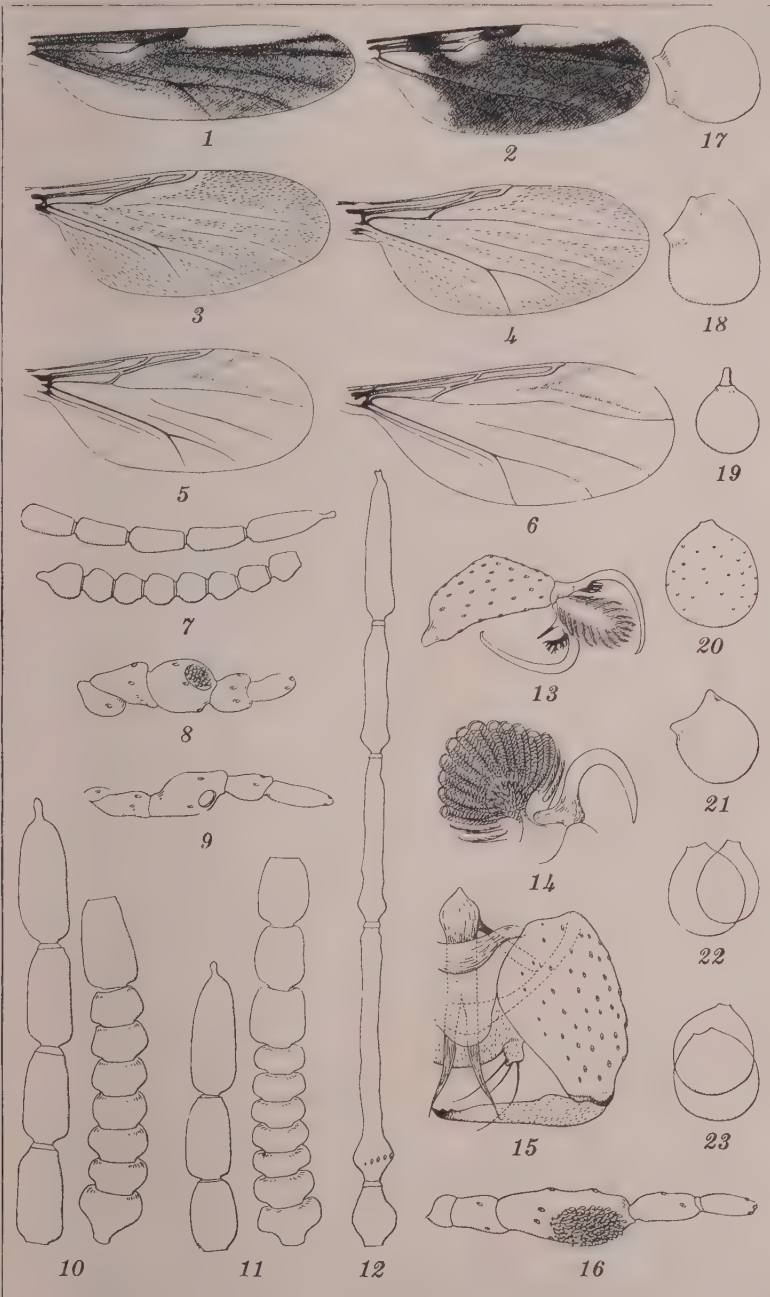


PLATE 1.

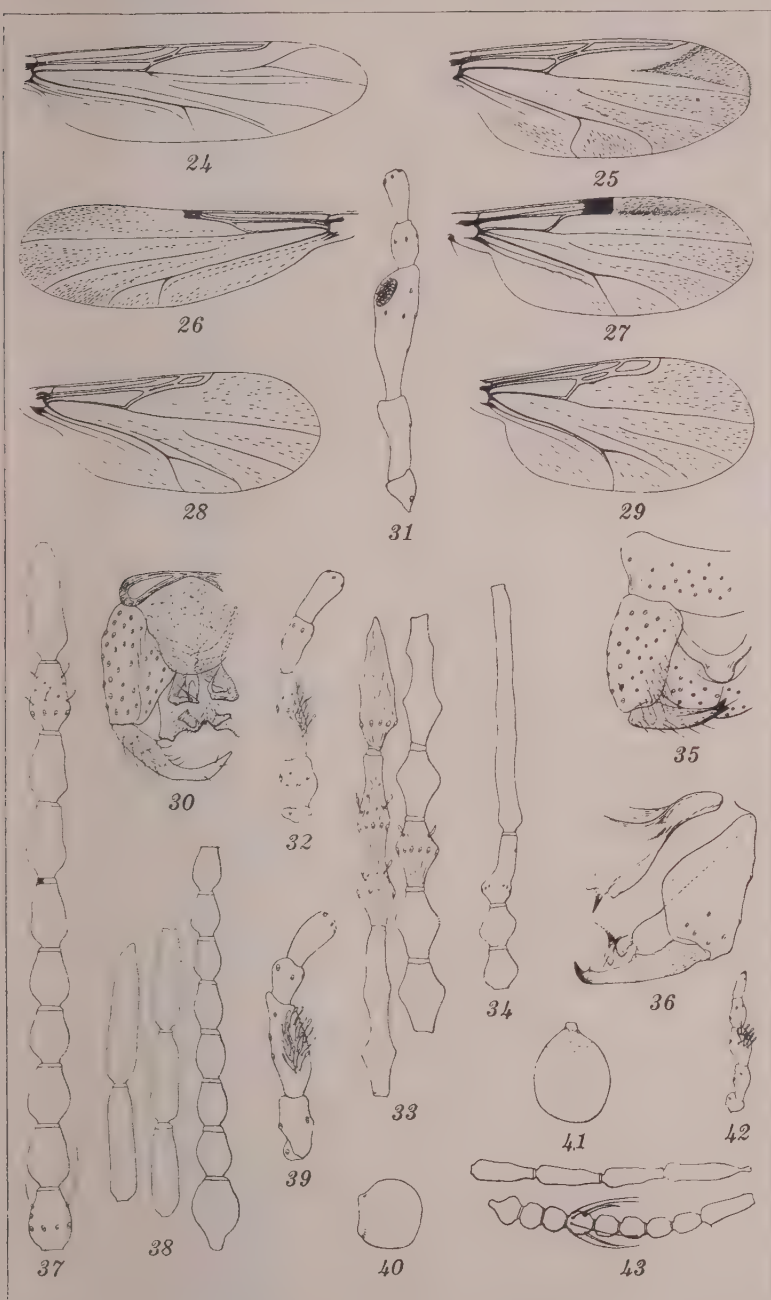


PLATE 2.

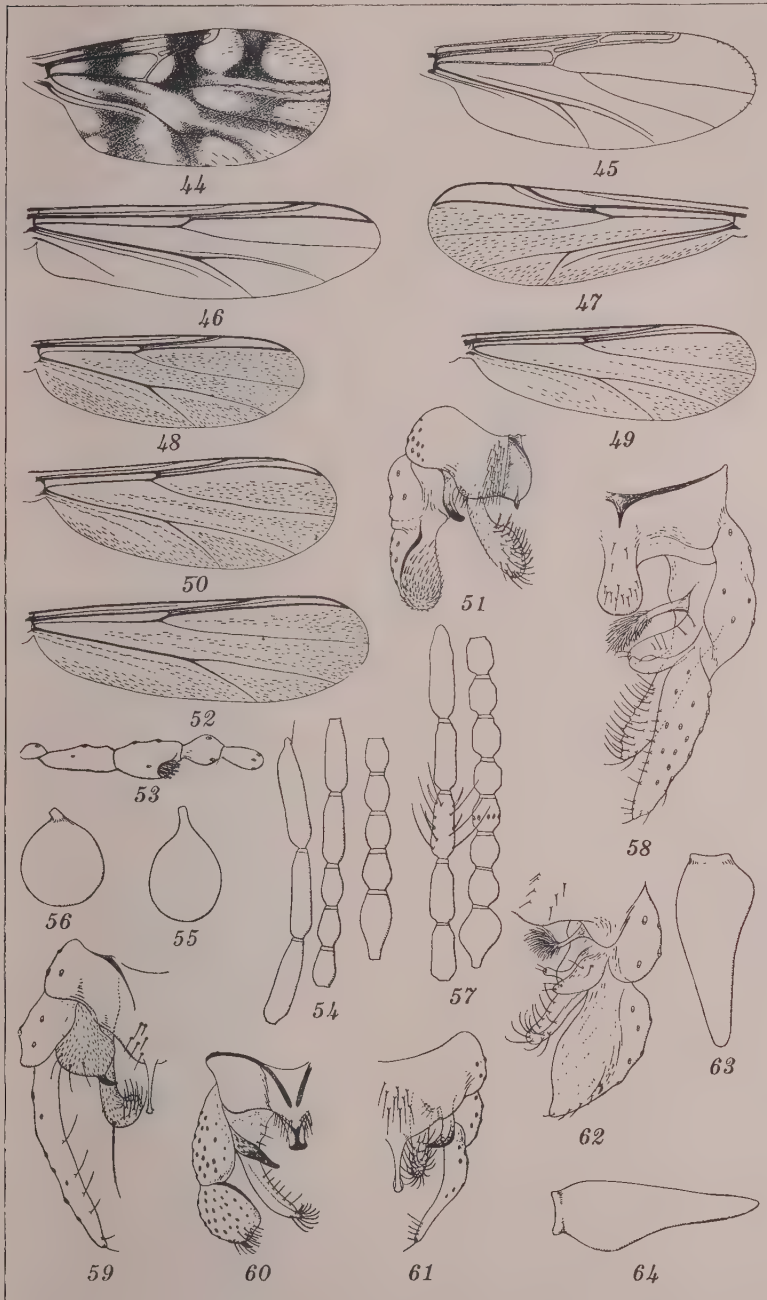


PLATE 3.

BOOKS

Books reviewed here have been selected from books received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEWS

Childless. A Study of Sterility, Its Causes and Treatment. By Sam Gordon Berkow. New York, Lee Furman Inc., 1937. 307 pp., illus. Price, \$3.

A book with a title like this one is often subject to superficial judgment. A perusal of the contents of the present book, however, convinces the reader that the author was guided by the most serious of motives. The subject is treated scientifically, yet its language is adapted to the potential lay readers, among which are about 2,000,000 childless couples in America alone, who need badly the information which it gives. The discussions on the so-called safe period theories are critical but sound. The fairly comprehensive bibliography at the end shows not only the thorough manner in which the author prepared himself before writing the book, but it is also a very useful guide to readers who may wish further light on any particular phase of the broad subject of sterility or childlessness.—C. R.

The Air and Its Mysteries. By C. M. Botley. With a foreword by Sir Richard Gregory. London, G. Bell and Sons Ltd., 1938. 296 pp., front., illus. Price, 8s/6d.

Of popular science books there is no end, and they run from good, through indifferent, to bad. Miss Botley's book is decidedly of the better class. It is not, as might at first be imagined, a popular treatise simply on the weather. Its scope is broader, covering in simple, entertaining fashion a host of interesting facts concerning our atmosphere, its constituents, its movements, its varied phenomena of sound and light, and other aspects. It has, in other words, the scope of a very general meteorology. The book is "crammed" with interesting facts and incidents; in fact, in endeavoring to pack as much as possible into a short space, the author's style at times becomes slightly cryptic or

obscure. But this is a very minor fault, and we willingly recommend this book to those who wish an up-to-date but popular account of our atmosphere and its ways.—C. E. D.

Child Psychology. By Noel B. Cuff. Louisville, Kentucky, The Standard Printing Co. Inc., 1937. 299 pp. Price, \$2.50.

This book is intended as an elementary textbook in child study, based on results of experiments and investigations on child behavior. It utilizes the opinions of teachers of child psychology and outstanding books and research studies on the subject. It discusses in a clear-cut, brief, and pointed way the physical, emotional, and mental problems in every stage of child development. The organization is simple and flexible, hence adaptable to the particular needs of the teacher and the pupil. The presentation of the different units considers the viewpoints of several schools of psychology, especially the behavioristic and the gestalt schools. Emphasis is placed on facts so that beginners in the study of child psychology can readily get the principal points in the discussions. The principal features are the discussion questions, some simple experiments which may motivate the work, and objective test items at the end of each chapter. The selected references and references preferred by students will prove beneficial to the students.

The first chapter outlines the subject matter as gathered from a canvass of preferences of professors and students of child psychology, and the methods and objectives of a course in child study. Chapter II treats of the original nature of the infant, the theories of heredity and the prenatal influences, and enumerates some inheritable traits. Chapters III to VI discuss the physical and mental growth, the emotional development, and the nature and characteristics of the original tendencies as manifested in the different stages. A separate chapter is devoted to the problems and varieties of adjustment and the guidance necessary to develop an integrated child. The development of speech, the learning processes and meanings, and thinking and reasoning are clearly presented. The problems on socialization and guidance and the measurement and prediction of individual differences in mental ability are also discussed and should be very helpful to the student. The book should prove to be a suitable text in a course in child psychology.

—B. A. S.

Growth in Intellectual Ability as Measured by Repeated Tests. By Frank N. Freeman and Charles D. Flory. Monographs of the Society for Research in Child Development, Volume II, No. 2 (Serial No. 9). Washington, D. C., Society for Research in Child Development, National Research Council, 1937. 116 pp., illus. Price, paper, \$1.

The purpose of this report is to supply evidence in support of conclusions formulated by psychologists and educators regarding intellectual growth and development. The study on which it is based covers a period of fifteen years, and was conducted by means of repeated tests. The tests and subjects used were well selected, a testing program was followed, and the findings were tabulated and interpreted. The V A C O—vocabulary, analogies, completion, and opposite tests, were used. The major problems were the rate of growth at successive ages or periods as expressed in the growth curve, the terminus of growth or the age at which it ceases or approaches zero in rate, individual and sex differences in these respects, and the relations between individual differences in level or degree of ability and differences in rate of growth or fluctuations in rate. According to the study, the curves of individuals, groups of individuals, or groups classified according to ability, vary from the average; the age at which intellectual growth ceases, for the group taken as a whole, is not earlier than nineteen (supported by tables and graphs); differences between sexes seem to be negligible, contrary to the common belief that intellectual growth of the two sexes differ because of the difference in rate of physiological development and of physical growth; individual differences in the rate of intellectual growth, especially in the fluctuations in rate and the form of the growth curve, are very significant. The findings are illustrated by tables and curves of distribution which are found throughout the pages of the report. At the end samples of the tests are given—vocabularies, analogies in different forms, sentence completion, and opposites.

The report will be very helpful to teachers of both psychology and child study and in the elementary schools.—J. C.

The Technical Analysis of Ores and Metallurgical Products. By Franklin G. Hills. 2d ed. rev. New York, Chemical Publishing co., inc., 1939. 250 pp., illus. Price, \$3.

This book treats concisely both rapid and refined accepted methods of analysis, not only of usual ores and metallurgical

products but also of ores of rare occurrence. It contains discussions on careful selection of methods, interfering elements, dissolving of ores, and other analytical information not available in other similar text books.

The student as well as the experienced metallurgical chemist and engineer will find this a very handy guide and reference book in the laboratory.—R. A.

Soil and Human Health: A call to Action. By Edgar J. Saxon. London, The C. W. Daniel Company, Ltd., n. d. 8 pp. Price, 3d.

This leaflet is a summary of an address the main theme of which is the soil as a factor in the maintenance of human health. The author brought out his theme through a brief discussion of the nature and function of the soil in providing man with his basic necessities for a healthful existence. His definitions of soil in general and what he calls "living soil" are very practical and intelligible. The account of man's endeavor to extract his daily bread from the soil, while brief, is instructive. The author emphasizes the importance of "ten radical requirements" in working out and treating the soil for sustained productivity which is very essential in the preservation of human health. He closes his summary with a concise but convincing exposition of the "disastrous pseudo-scientific blunders" which the author believes to be responsible for "widespread malnutrition, subhealth and disease" among the English people, and among all peoples.

The leaflet is highly informative and very interesting.

—Q. A. E.

Zur Entdeckung der Insulinschocktherapie bei akuten Geisteskrankheiten, Insbesondere bei der Schizophrenie. By Dr. Julius Schuster. Budapest, Pester Lloyd-Gesellschaft, n. d. 90 pp., illus. Price, paper, 2 Pengö.

The author puts forth and substantiates his claim (against Sakel) for priority relative to the insulin treatment of acute mental conditions, especially of schizophrenia, by citing his lecture given before the medical society in Budapest as far back as April, 1926. He deals at length with histopathological studies of the glia and nerve ganglion cells in various mental diseases. In schizophrenia the author believes that the essential and determining disturbance lies in defective metabolism of the phosphatides and related substances. Although clinical symptoms in schizophrenia strongly point to the thalamic region, no

histopathological changes were demonstrable there. A number of case records illustrate the result and successful effect of insulin treatment. In the concluding chapters of this interesting booklet the author discourses on laws of heredity and factors influencing it.—C. M. H.

Strange Animals and Their Stories. By A. Hyatt Verrill. Boston, L. C. Page & Company, 1939. 235 pp., front., illus. Price, \$2.50.

This book is a popular account of strange forms and habits of a number of wild animals, the word "animal" being made synonymous with "mammals and quadrupeds" and not including birds, reptiles, fishes, shells, or other forms of lower animal life. Although based on scientific data and observations, the book is written in a popular form which makes it readily readable to persons without or with very little zoölogical background. To Philippine readers, students and scientific workers the book should be of interest because it sets forth phenomena which, perhaps, may be also true with a number of Philippine mammals. Although devoid of "juggernauts," as elephants, rhinoceros, hippopotamus, tapirs, and the like, the Philippines has a number of animals which may also be rightly called strange. Among these are the spiny ant-caters, flying lemurs, tarsiers, civet cats, fruit bats, mouse deer, and tamarao. The author, who has many years of jungle experience with wild beasts, may find a number of strange things about the few mammals the Philippines has.—H. A. R.

Some Fundamental Aspects of the Cancer Problem. Symposium Sponsored by the Section on Medical Sciences of the American Association for the Advancement of Science, Atlantic City, New Jersey, December 29, 1936–January 1, 1937. Edited by Henry Baldwin Ward. Occasional publications of the American Association for the Advancement of Science. New York, The Science press, 1937. 248 pp., illus. Price, cloth, \$2.50; paper, \$2.

These papers constitute the symposium on cancer sponsored by the section of medical sciences of the American Association for the Advancement of Science, held at Atlantic City, New Jersey, from December 29, 1936, to January 1, 1937. There are 31 papers in all, classified under five different topics; namely, seven under heredity and constitutional factors, nine under induction, stimulation and inhibition of tumorous growths, five under metabolism of cancerous tissue, seven under radiation, and three under general discussion of the cancer problem. The most important of these papers are those bearing on the genetics

of cancer and its localization, and the factors of heredity, age, and acquired hypersensitiveness in relation to cancer; chemical aspects of the cancer work and the indications from chemical structures regarding the relationship between carcinogenic action and the sex hormones; production of tumors by chemical agents; relation of oestrin and other hormones to tumor formation in the breast; relation of protein metabolism to malignant growth; combined effects of Roentgen radiation and fever upon malignant tissue; recent progress in the study of radium poisoning; and changes and modifications in the conception of carcinoma. The latter group of papers brings out some facts borne out by rigid observations, which change our concept of carcinoma for the better, in the sense of enabling us to make an earlier diagnosis of the disease—C. R.

Comparative Psychology. A Comprehensive Treatise. Volume I. Principles and Methods. By Carl J. Warden, Thomas N. Jenkins and Lucien H. Warner. Psychology Series. New York, The Ronald press company, 1935. 506 pp., illus. Price, \$4.50.

The first four chapters give a broad historical and theoretical approach to the viewpoint and problems of comparative psychology. A detailed discussion of the experimental methods of studying the behavior of the organism is effectively presented. Chapters V and VI offer in a logical and critical way the methods of testing the receptive and reactive capacities. The last chapter represents a comparative survey of the structure and function of the receptive, connective, and reactive mechanisms of living organisms.

The book should be a very effective textbook for students in advanced comparative and genetic psychology. It may also serve as a useful reference book in experimental psychology courses, the psychology of learning and physiological psychology. It is worded and written within the grasp of any intelligent person who is at all interested in and familiar with the subject.

—M. M. S.

RECEIVED

BOTLEY, C. M. *The air and its mysteries.* With a foreword by Sir Richard Gregory. London, G. Bell and Sons, Ltd., 1938. 296 pp., front., illus. Price, 8s/6d.

Chemical analysis of aluminium and its alloys. London, The British Aluminium company, Ltd., 1938. 85 pp., front., illus.

FLANNAGAN, ROY C. *The story of lucky strike.* Richmond, 1938. 94 pp., illus.

- FLECK, HENRIETTA C. A nutrition manual. Ann Arbor, Michigan, Edwards Brothers, inc., 1938. 180 pp. Price, \$1.75.
- JULIANELLE, LOUIS ALPHONSE. Etiology of trachoma. New York, The Commonwealth Fund, 1938. 248 pp., pl., map. Price, \$3.25.
- KOVACS, RICHARD. The 1938 Year Book of physical therapy. Chicago, The Year book publishers, 1938. 486 pp., illus. Price, \$2.50.
- LEA, C. H. Rancidity in edible fats. New York, Chemical publishing co., inc., 1939. 230 pp. Price, \$4.
- LEITH, C. K. Mineral valuation of the future. New York, published for the Seeley W. Mudd Fund, by the American institute of mining and metallurgical engineers, 1938. 116 pp. Price, \$1.50.
- SIMPSON, S. LEVY. Major endocrine disorders. Foreword by Sir Walter Langdon-Brown. London, John Bale medical publications, ltd., 1938. 184 pp., illus. Price, 10s/6d.
- WHITLOCK, JOHN H. Practical identification of endoparasites for veterinarians. Minneapolis, Burgess publishing company, 1938. 37 pp., mimeoprint., illus. Price, \$1.25.

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CONTENTS

	Page
TOPACIO, TEODULO. An outbreak of hæmorrhagic septicæmia in Indian buffaloes	125
LAVA, V. G. Some notes on the utilization of Philippine low-grade chromite	133
MILLER, CAREY D., and RUTH C. ROBBINS. Chemical analysis and vitamin assays of Opihi, the Hawaiian limpet.....	141
ROXAS, HILARIO A., and GUILLERMO J. BLANCO. A new go- bioid fish from Luzon	165
ALEXANDER, CHARLES P. New or little-known Tipulidæ from eastern Asia (Diptera), XLII	169
TOKUNAGA, MASAAKI. Ceratopogonidæ and Chironomidæ from the Micronesian Islands: with biological notes by Teiso Esaki...	205
BOOKS	231

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